# COMMERCIAL RAW MATERIALS

TOOTHAKER

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COTTON-PICKING IN MISSISSIPPI

# COMMERCIAL RAW MATERIALS

THE ORIGIN, PREPARATION, AND USES
OF THE IMPORTANT
RAW MATERIALS OF COMMERCE

BY

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# PREFACE

A general knowledge of the nature and of the uses of the materials of commerce is important to every business man. He must of course have an intimate knowledge of the things which enter into his own industry, but he should not be ignorant of other products with which he comes in contact. An intelligent comprehension of the world's industries means a knowledge of the life of other countries and a mental grasp of international relations. A widespread knowledge of such matters is one of the things which will fit the coming generation to keep our nation in its proud position as the richest in the world.

Let no one scorn this as materialism. The golden days of art in Greece were made possible by the wealth of able business men who carried on a great commerce through the known world. They paid great architects, sculptors, and literary men of their age to do the things that make us remember them today. Without great wealth as a basis this world could never have developed civilization, art, or culture.

This book presents some of the most important facts in regard to the identity, localities of production, methods of preparation, and uses of the important commercial products. It has been compiled as a result of more than twenty-five years' experience as curator of the Philadelphia Commercial Museum. The author has had charge of what is possibly the most complete collection of commercial substances in the world. This museum work has been supplemented by contact with business men and by travel and observation in the United States and foreign countries. Acknowledgment is due Professor J. Paul Goode for permission to use his homolosine map projection of the world in this book.

CHARLES R. TOOTHAKER

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## FOODS

The foods which are of international commercial importance are, first of all, those which can be kept in good condition for comparatively long periods. In addition they must be nourishing or especially palatable. Among foods of vegetable origin the cereals take first rank commercially. They are the seeds of cultivated grasses, and the most important of them is wheat. Fresh meat is now handled and shipped in a way which was not possible fifty years ago, because during that period there have been great advances in the speed of transportation, both by land and by water, and in the perfection of cold storage.

Dried foods—meat, fish, fruits, and vegetables—have also increased in importance, but it is in canned goods of all kinds that the world's trade has made the most wonderful development. The variety of food now offered for sale throughout practically the whole world is astonishing compared with conditions less than half a century ago. To cite only three examples, there are few places where one cannot buy canned salmon from Alaska, canned pineapple from Hawaii, or condensed milk either from the United States or from Switzerland.

### CEREALS

**Wheat** (*Triticum sativum*, var. *vulgare*, *durum*, etc.). Wheat is the most nutritious cereal, and commercially the most important one. It has been cultivated since very ancient times and, in common with other grains, was referred to as "corn" before maize was known. Even now, in England, the word "corn" is commonly understood to mean wheat. Its value as

food is due to the fact that it is palatable, for it contains both gluten and starch, and its composition shows that it has in it the important body-building elements. It is the chief grain used for human food in western Europe, in North America, and by the white race in South Africa and in Australia. Within recent years the use of wheat flour has greatly increased. The poorer people of Europe, who used to depend almost entirely on oats and rye, now eat a great deal of wheat, and millions of Japanese and Chinese, who lived on rice a generation ago, are better nourished today because of the addition of wheat to their diet.

Wheat thrives best in temperate climates, but it is raised even in the cool mountainous regions of the tropics. The United States is the greatest wheat-producing country because of favorable climate and soil, the use of improved agricultural machinery, and economical methods of handling and transportation. The wheat industry of this country, more than any other one thing, stimulated the invention and development of agricultural machinery. The mechanical reaper was followed by a combined reaper and binder run by horse power. This was soon combined with a thrasher. Then came the header, which left the straw standing where it grew and cut off only the heads of the wheat. Steam power made possible still larger machines for plowing, planting, and harvesting, and now gasoline tractors enable even a small farmer to do his work with the help of but few men and few horses. The inexpensive methods of wheat culture which are appropriate to the large farms of sparsely settled regions like Dakota, Argentina, or Australia give large harvests of wheat, but the yield per acre is easily doubled in England, France, and Germany, where on smaller farms it is possible to till the land more carefully. Not only does Europe produce more wheat per acre, but the total amount of wheat harvested annually in Europe up to 1910 exceeded the total crop of the rest of the world.

Wheat is handled in the United States and Argentina largely in bulk; it is loaded loose (not in bags) on cars or in boats,

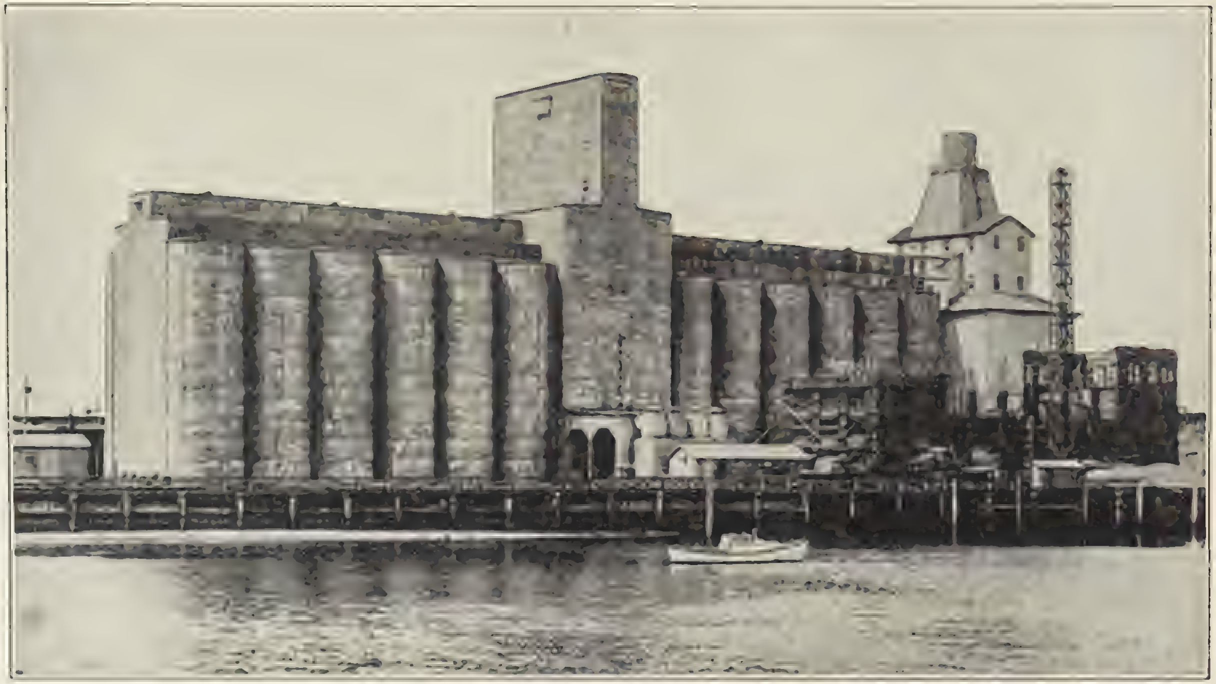


FIG. 1. Grain Elevator, Astoria, Oregon

This great concrete building on the Columbia River is an example of many such elevators where grain is stored and handled in bulk

is transferred by machinery, and is stored in grain elevators. In other countries the grain is usually stored in bags, and the cost of handling is therefore considerably greater.

European countries are all large producers of wheat, but only Russia and Rumania grow more than they need at home. The other countries must import from them or from Argentina, Australia, the United States, Canada, Algeria, or India. Increased population in the United States is one of several factors which are rapidly lessening the export of wheat from this country. Among the important wholesale markets for wheat are New York, St. Louis, Chicago, Minneapolis, Buenos Aires, Odessa, Bombay, and Sydney. An abundant crop of wheat in the world usually means extensive buying and selling, low-priced flour, and general business prosperity, whereas a short wheat crop is promptly reflected in advanced prices for other foods and in difficult conditions in many lines of trade.

Wheat, like many other cultivated plants, has developed hundreds of varieties, known to growers under different names. Wheat is classified commercially as "hard" and "soft." The hard, or "flint," varieties contain a large percentage of gluten or protein; soft wheats contain more starch and less gluten. Some varieties, known as durum wheats, are especially hard and flinty; these are particularly useful for making macaroni. New varieties of wheat, brought from semiarid regions in Russia, Turkestan, and Algeria, and new methods of agriculture have greatly increased the wheat-growing area of this country. Wheats are also classified according to their color as "red" or "white" and according to the season as "winter" or "spring." Winter wheats are sown in the autumn and are harvested in early summer; spring wheats are sown in the spring and are harvested in late summer.

Wheat is graded commercially as No. 1, No. 2, No. 3, or No. 4, according to quality. Standard quotations give prices on a certain wheat as "No. 2 red winter," "No. 1 Northern," and so on.

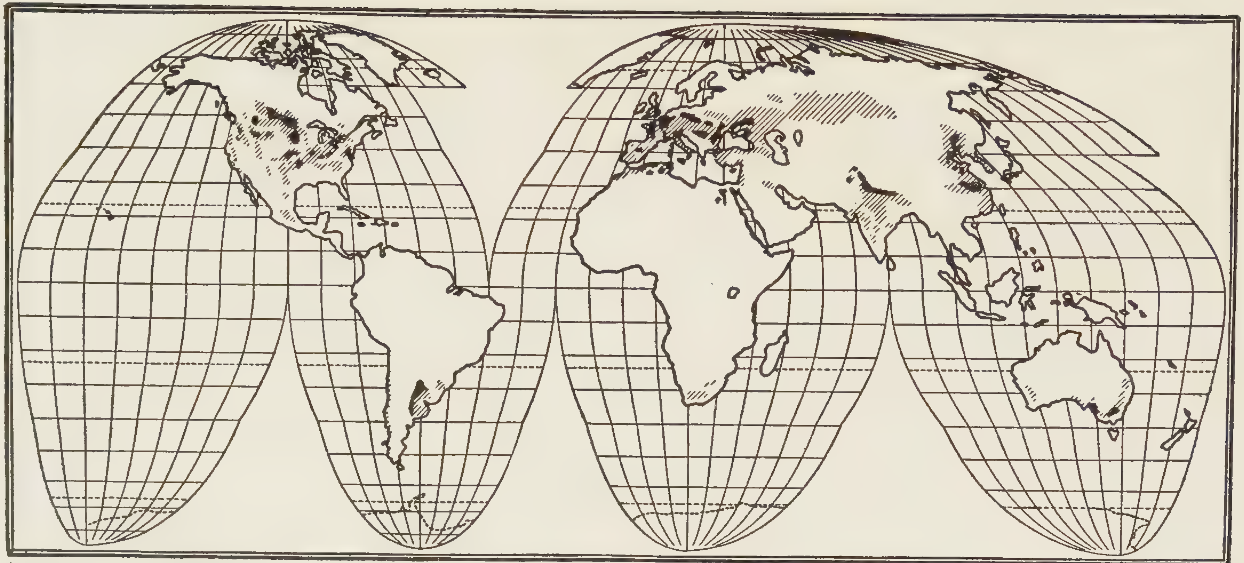



FIG. 2. Areas of Wheat Production

Wheat is the food of the white race. Where modern industries develop and wealth increases, wheat is used more and more

Wheat is ground in great mills where heavy steel and porcelain rollers have taken the place of the old-style millstones. After being ground it is separated by sieves and silk bolting cloth into bran, middlings, and flour of different degrees of fineness. Flour is sometimes made by grinding only one kind of wheat, sometimes by mixing two or more kinds. White flour (patent flour) is sifted until the darker parts of the grain have been removed. If the final sifting is through bolting cloth of great fineness, the flour may be of a very white color and may contain little but starch. To the extent that the gluten is removed, white flour lacks the highest nutritive value. The demand for a white flour, combined with the desire of every mill to turn out the greatest amount of flour from a given quantity of wheat, caused the development of a process of bleaching by means of which a flour is made to look white. Whole-wheat flour contains all the gluten and practically the full nutritive value of wheat, but does not contain the bran. Graham flour contains all parts of the grain, including even the bran. Commercially the chief value of bran is as food for stock, for which purpose it is mixed with molasses, oil cake, gluten meal, middlings, and other things. Farina, or semolina, is the fine middlings from milling hard wheat.

Minneapolis and Buffalo are the most important centers of the milling industry in the United States. The export of flour from the United States, like the export of wheat, is decreasing owing to the rapidly increasing needs of our own population.

Macaroni, spaghetti, and noodles are preparations made of wheat-flour paste. Glutinous wheat is necessary for their manufacture. They are especially popular among people of the Latin races in Europe and South America. Some macaroni is made in the United States. Breakfast foods made of wheat (shredded wheat, flaked wheat, puffed wheat, etc.) have grown rapidly in popularity during recent years. Wheat grits and starch are also made of wheat.

**Barley** (*Hordeum sativum*, var. *vulgare*). Barley is chiefly used for brewing beer and in some places as stock feed. It is cultivated in north and central Europe as far as northern Norway, in Tibet, in northern China, in India, in Japan, and to a considerable extent in the United States and Canada. In warm countries it thrives only in the mountains.

For household use pearl barley is used in preparing soups, gruels, and the like. Barley flour has a limited use in the United States and Europe. In Scandinavia it is used for making bread.

Malt is made from barley (or sometimes from other grains) by spreading it, wet, on the floor of a dark room, where it swells and sprouts. It is then dried, screened, ground, boiled with hops, and allowed to ferment to make beer. During the process of sprouting, or germination, a ferment known as diastase is produced, which converts the starch of the grain into dextrin and maltose. Maltose is a kind of sugar, and this, in fermentation, produces alcohol. It has been found possible to use malt as a basis for soft drinks containing almost no alcohol yet having the bitter taste of beer, which many people think pleasant, and containing a considerable amount of maltose, which is decidedly nourishing. It is possible even to retain in these drinks a fair amount of diastase, which is a distinct aid to digestion. Barley sugar, or maltose sirup, is prepared commercially for the use of bakers and confectioners.

**Rye** (*Secale cereale*). Rye is the chief breadstuff in Russia, Scandinavia, and parts of Germany. It is cultivated, like wheat, in "winter" and "spring" varieties, but grows in a colder climate and on poorer soil than does wheat. Rye is one of the grains used for distilling, and it was formerly much used in the United States for making whisky. It is the base for Russian vodka. A relatively small amount of rye flour is used in this country in making bread. Rye straw is long and tough. It is used for making braids for hats, to a less extent for making ropes and mats, and, by the poor people in parts of Europe, for thatching. Russia, Germany, and Poland are the greatest producers of rye.

The United States furnishes only a very small part of the world's production of this grain.

**Oats** (*Avena sativa*). Oats are most important as horse feed. As oatmeal they are used for human food in Scotland, Ireland, and other countries. They flourish in a cooler and moister climate than wheat and are grown over a large area. In this country Iowa, Illinois, and Minnesota are the greatest oat-producing states. In Europe oats grow most largely near the Baltic coasts of Russia and Germany and in Ireland, Scotland, France, Hungary, and Norway. Russia and the United States grow more oats than do other countries.

**Corn.** Indian corn, or maize (*Zea mays*), is the most valuable cereal crop of the United States as well as of Brazil, South Africa, and various other countries. Eighty per cent of the entire production in the United States is used on the farms where it is grown. Thirty per cent of the crop is fed to hogs, an equal amount to horses and mules, and much to chickens and cattle. About ten per cent is used for human food.

The United States produces three quarters of the corn crop of the world, the remainder being raised in Hungary, the states of the Balkan Peninsula, Italy, Spain, France, Canada, Egypt, South Africa, Australia, China, Mexico, and Argentina. The principal corn-producing states are Iowa, Illinois, Nebraska, Missouri, Kansas, Minnesota, Indiana, and Ohio. Argentina is the greatest exporter of maize, followed by the United States, Rumania, and Russia. Corn is less easy to handle in commerce than wheat, owing to the fact that it absorbs moisture easily and is therefore inclined to mold or become musty. The United States exports very large amounts of corn meal, especially to the West Indies and other tropical countries, where it is an important food of the poorer people.

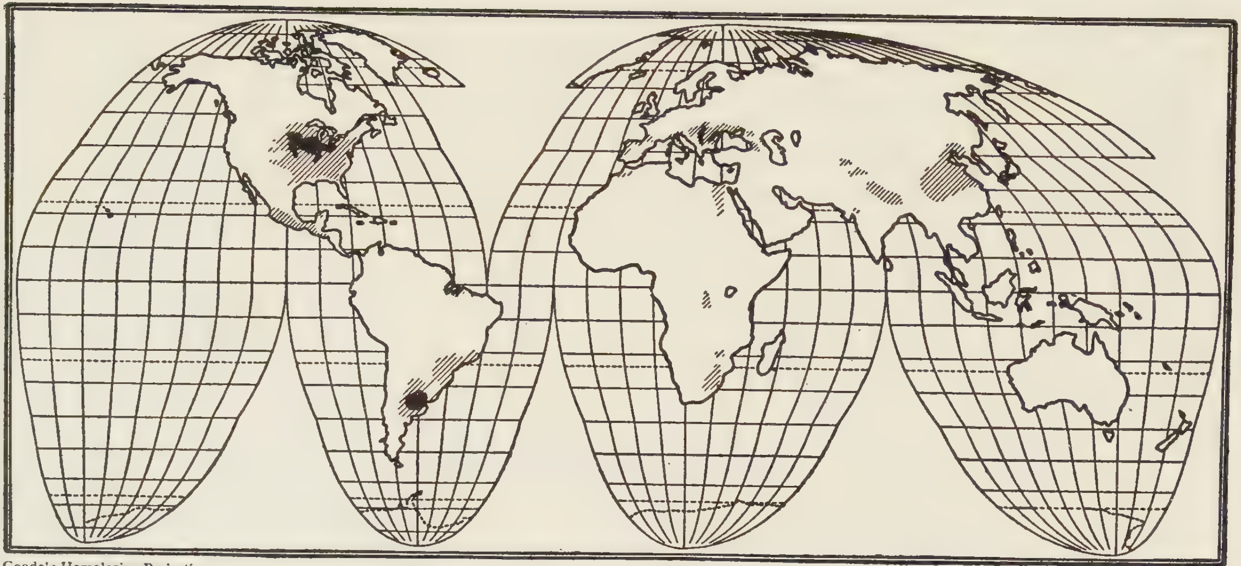
In Europe the name "corn" is applied to wheat, oats, and other grains. In various parts of Europe maize is known as Turkish wheat, as Spanish corn, and as Egyptian corn; in Egypt it is called Syrian durra; in South Africa it is termed mealies.

Fig. 3. Corn Harvest, Umtali, Rhodesia

American grain on a South African farm being hauled from the field by a traction engine made in the United States

- CORN (Maize) | The whole green plant | Fodder, ensilage
  - Young ear
    - Fresh and canned for human food
    - Husks for mattresses, mats, etc.
  - Ripe ear
    - Fodder
    - Grain (or seeds)
      - Food for stock
      - Cracked corn, corn meal, corn grits, hominy, breakfast foods
      - Beer, whisky, alcohol
      - Starch
        - Dextrine
        - Glucose, corn sirup, grape sugar
        - Caramel
        - Food and manufacture
      - Germs
        - Corn oil
          - Table oil
          - Cooking-oil
          - Soap
          - Rubber substitute
        - Oil cake for cattle food
      - Bran, Gluten
        - Cattle food
    - Cob
      - Fuel
      - Pipes for smoking
    - Silk, medicinal
  - Stalk
    - Fodder
    - Fertilizer
    - Leaves
      - Cattle and poultry food
      - Paper stock
      - Fertilizer
    - Corn-pith cellulose

There are many varieties of maize, differing in size, color, and composition. Some are rich in starch; others are rich in oil. The numerous varieties are due partly to the influence of soil and climate and partly to the efforts of growers to develop certain characteristics, such as a large or a small percentage of starch. The two chief types are "flint" and "dent," and most corn is either white or yellow, although red corn is fairly common and some varieties are nearly black in color. The commercial grades of corn are designated by numbers 1, 2, and 3 and usually as either white, yellow, or mixed. Outside of feed corn the principal types (all of which are grown in relatively small amount) are sweet, or sugar corn, pop corn, and a variety with large cobs, cultivated especially for making corncob pipes for smokers' use.



Goode's Homolosine Projection

FIG. 4. Areas of Corn Production

Corn is the staff of life for thousands in the great interior of Brazil, in Peru, Colombia, and Venezuela, as well as for African negroes south of the equator. It is raised in Alaska and in Australia. The shading shows only areas of large production

Corn is the most important human food in some sections of the southern United States, in Mexico and Central America, and in parts of Italy, the states of the Balkan Peninsula, and Egypt. Green corn is rarely eaten except in the United States, where it is used both fresh and canned. Canned sweet corn has an extensive sale. Breakfast foods made of corn (corn flakes etc.) are very largely used in the United States. Corn meal (yellow or white) is mixed in stock feed and is an important human food. The negroes and poorer whites of the southern United States eat a great deal of corn bread and corn-meal mush. One thing which prevents the wider use of such food is the fact that it is not appetizing when it is cold, corn being inferior to wheat in this respect. In Italy many of the peasants regard polenta, a coarse corn-meal porridge, as the staff of life. Similarly, in Mexico the peon's staple food is a sort of griddle cake made of corn meal and called tortilla. White corn flour has a rather limited use and is not manufactured in very large quantities. Cornstarch is often substituted. Hominy is made by breaking certain flinty varieties of white corn into coarse pieces and removing the germs and the hulls. Hominy grits or corn grits are merely crushed finer. Hulled corn, or lye hominy, is similar to whole hominy. Cracked corn is fed to chickens and live stock. Pop corn, a variety of corn with small grains, is peculiar for the fact that when it is heated, it bursts and swells up, forming light white lumps. Popped corn has a fairly wide sale on street corners and at many places of amusement.

In the United States a great deal of cornstarch is prepared which is used for food, for laundry purposes, and for stiffening textiles during their manufacture. Equally important, perhaps even more so, is the use of starch for making dextrine, glucose, and grape sugar and as a source of alcohol. During the process of making starch the germs of the corn are separated, as are also the bran, or hulls, and the gluten. The two latter are generally sold together under the name of "gluten feed" for stock.

The germs of corn contain about half their weight in oil. Corn oil is today one of the very important and useful corn products and is produced in large amounts. The material remaining after the oil is pressed is called oil cake and is used for cattle food. Its feeding value lies in the fact that it contains much protein. A large percentage of the oil cake is exported to Europe, and some is ground and sold as oil-cake meal.

The fresh corn plant is a very important stock feed, and enormous amounts of unripe plants are used as green fodder and as ensilage. Cattle readily eat also the dried leaves and stalks, and large quantities go into chopped feeds after the grain has been harvested. Paper is sometimes made from the leaves and stalks. Corn pith was formerly used for packing between the double hulls of ships, because when it absorbs water it swells up and thus closes a hole made by a cannon ball. Corncobs are an excellent fuel, but are of value only to the farmers who grow the corn.

**Rice** (*Oryza sativa*). Rice is the principal food of one third of the people of the world. It is not so important as some other grains in general commerce, as it is largely consumed in the countries which produce it. It is the principal crop and the main food in southeastern Asia, from India to southern Japan, and in many of the islands of the Pacific. The United States produces, chiefly in Louisiana, California, Arkansas, and Texas, about half as much rice as it consumes, importing the remainder from eastern Asia. Rice is an important crop in Brazil, Guiana, Central America, Egypt, Italy, on the west coast of Africa, and in Madagascar.

There are three important kinds of rice in cultivation: common swamp (lowland or wet) rice, upland (hill) rice, and glutinous rice, besides several hundred cultivated varieties which vary considerably in the size and shape of the grain. Rice needs a warmer climate than do other cereals, and the common varieties require a bountiful supply of moisture; therefore it is usually grown either in places which are natu-

rally swampy or else on fields which are kept flooded during the greater part of the growing season. Upland rice grows with no more water than would be required for a crop of wheat, but this type is relatively unimportant and is little cultivated. In Japan, China, India, and, in general, throughout the Far East there is not enough swampy land to grow the rice which is locally needed. The people have therefore developed on a very extensive scale the plan of terracing their hillsides, thus making small fields which can be kept flooded. The agricultural methods are primitive, as are also the ways of cleaning the grain, but in these countries rice is a crop produced with an abundance of cheap labor. Extensive irrigation and modern agricultural methods have made it possible to grow rice on a large scale on the prairies of Louisiana and Texas. The chief wholesale markets for rice are Yokohama, Nagasaki, Hongkong, Rangoon, Bombay, Amsterdam, and New Orleans. It is exported in largest amounts from India, Indo-China, Siam, and the Straits Settlements.

Rice with the hull on is called rough rice, or paddy. The hulls are loosened by rapidly revolving millstones and are then fanned away from the grain. Rice hulls are used in rather small quantities for packing chinaware, but they are used chiefly as fuel. This is the chief source of power at many rice mills. In burning the hulls a good deal of carbon and soot is formed the disposal of which is often a problem. Some of this carbon is used in clarifying sugar. Rice hulls can be made into briquettes for fuel by the use of a suitable binder, and attempts are sometimes made to dispose of them in this way.

When the grain has been freed from the hulls, it is still covered by a thin cuticle, which is loosened by a machine called a huller. This by-product, known as rice bran, contains much of the natural nourishment of the grain and is sold to mix with cattle feeds. The rice is now fairly white in appearance, but the market demands a more attractive article. Another machine therefore rubs the rice between leather rollers and wire

FIG. 5. Planting Rice in China

The lowlands of southern China are for hundreds of miles a succession of flooded rice fields. Cheap labor makes possible intensive cultivation and big crops

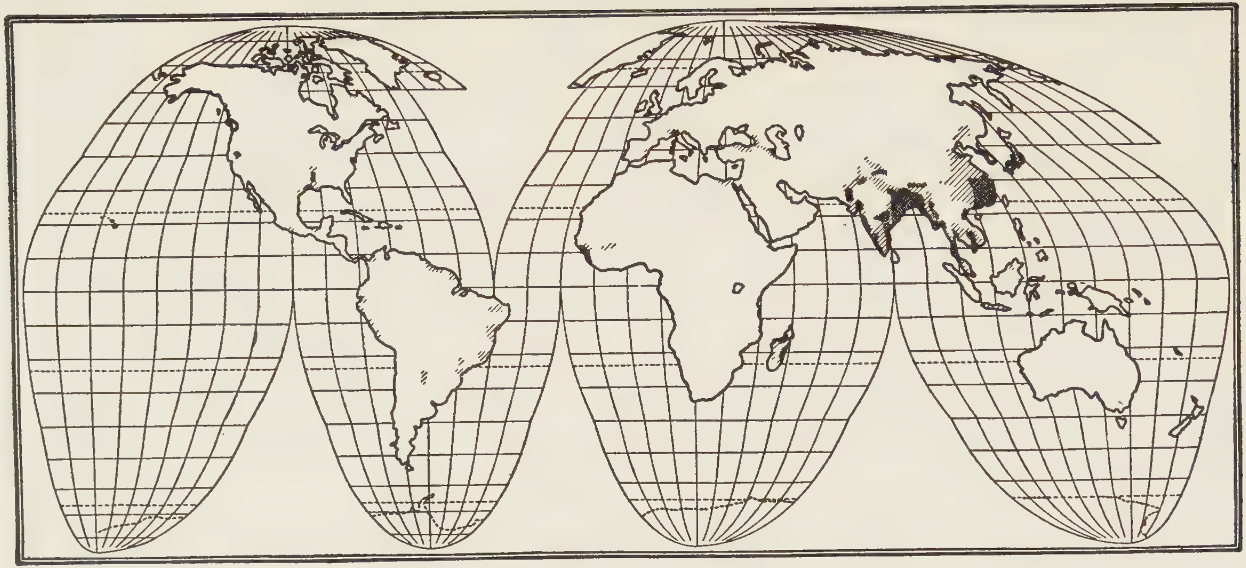
screens, which rub off a white powder known as rice polish. The grains are now called uncoated rice. Coated rice is prepared by polishing the grains with glucose and talc. Coated rice should be thoroughly washed before it is cooked in order to remove the glaze, which is of no value except to please the eye of the customer. The commercial grades of rice are known by numbers 1, 2, etc. and also by names such as "fancy," "good," "broken," and so on. The selling price of the rice depends on its appearance, broken grains being salable at less than a quarter of the price of whole grains, although there is no difference in the nutritive value. A great deal of broken rice has been used by brewers in the United States. Rice is used by the Japanese in brewing their national drink, a weak alcoholic beverage called saké.

Rice consists almost wholly of starch, even in the so-called glutinous varieties. Rice flour, commercially called rice starch, has a limited use, for it does not contain enough gluten to form a satisfactory dough. It differs from rice starch in being a product made by grinding grain, whereas the latter is prepared, like other starches, by washing the softened grain and collecting the starch particles from the water (see Starches). Rice powder ("poudre de riz") for toilet use is mainly powdered talc or soapstone, although it sometimes contains a little rice flour.

Rice straw is used in Japan and China for making mats, ropes, bags, sandals, raincoats, and other articles and for thatching and bedding. Paper is sometimes made from it.

Rice paper (so called) is not made of rice but from the pith of a tree (*Fatsia aralia papyrifera*) that grows in Taiwan (Formosa).

**Millets; sorghums.** Millet, sorghum, and durra are other cereals, members of the family of grasses. Foxtail millet (*Setaria italica*), broom-corn millet (*Panicum miliaceum*), and sorghum (*Andropogon sorghum*) are among the most important. There are many varieties, some growing only a foot or two



Goode's Homolosine Projection

FIG. 6. Areas of Rice Production

Rice is the food of "swarming millions." This is typically the one cereal produced by cheap labor and patient toil

in height, and others attaining a height of eight or ten feet. The seeds vary considerably in size and also in appearance. Among the varieties are Italian millet, Hungarian millet, Japanese barnyard millet, Indian millet, pearl millet, broom corn, sorghum, Guinea corn, Kafir corn, durra corn, African millet, and milo.

Millet is an important forage plant in many parts of the world. It is used for food by millions of human beings in Japan, China, and India. The seeds of certain varieties of sorghum are largely eaten by native people in Africa and parts of Asia, being utilized in the form of meal and flour. A few mills in the United States make a small quantity of flour from millet and sorghum.

One variety of sorghum has a stalk which contains a sweet juice. This is cultivated in Tennessee and Kentucky for the purpose of making sirup. Another variety, broom corn, produces the heads which are used in making ordinary brooms.

Canary seed is produced by another grass (*Phalaris canariensis*) and is grown chiefly for the purpose of feeding birds. Job's-tears are the seed of a grass (*Coix lacryma*) which is cultivated on a small scale in many tropical countries. The seeds are edible, but owing to the hard, shiny gray shell their chief use is for making strings of beads and ornaments.

**Buckwheat** (*Fagopyrum esculentum*). Although not a member of the family of grasses, buckwheat is usually regarded as a cereal because its seeds are used like those of wheat, rye, and other grains. It is used for feeding poultry and for making flour for buckwheat cakes. In this country New York and Pennsylvania produce two thirds of the crop. It is also cultivated in Russia, Poland, France, and Japan.

## LEGUMES

**Beans; peas.** Beans and peas are common foods in nearly all countries, especially in the American tropics, where frijoles are a very important staple. Legumes are among the most nutritious foods, being rich in nitrogen and flesh-forming con-

stituents. Bean starch and bean flour contain much protein and are used in relatively small amounts.

There are a great many cultivated varieties of the common bean (*Phaseolus vulgaris*), differing in size, color, and flavor, known as kidney beans, marrowfat beans, French beans, haricot beans, and horse beans, or habas. The lima bean, the pigeon bean, and the green gram are different botanical species.

The soy bean (*Glycine hispida*) differs from almost all other members of the bean family in the fact that the seeds are rich in oil. The plant is a native of northeastern Asia, but it is now cultivated largely in Europe and America as food for stock. Soy beans are eaten by the people of Korea, Japan, China, and Manchuria, and soy-bean flour is sold to a limited extent in this country. The greatest commercial use of soy beans is for the manufacture of bean oil. Japan has for many years imported from China large amounts of soy-bean cake (the residue from oil-making) for use as a fertilizer. In Europe this oil cake is an important cattle food. Soy beans are used in Japan and China for making a curd which in some ways resembles cheese and is locally an important food. This material is prepared in very small quantities in America. A popular Japanese table sauce, *shoyu*, is made from soy beans and brine; it is exported in limited amounts.

The carob bean, locust bean, St. John's-bread, or algaroba, is the fruit of a tree (*Ceratonia siliqua*) which grows commonly in Mediterranean countries. The large pods are sweet and nutritious and are an important food for cattle in all the regions where the tree grows. Cyprus and Spain export considerable quantities to England for horse feed. Carob beans are often sold on street corners and are eaten by children in America. Algaroba pods are raised in Hawaii for cattle food.

Peas of several varieties (*Pisum arvense, P. sativum*) are cultivated in nearly all parts of the world. They are eaten fresh (green) and are sold, both canned and dried, in large quantities. France is a prominent exporter of canned peas.

Chick-peas, or *garbanzos* (*Cicer arietinum*), are cultivated in Mexico, Central America, India, and southern Europe.

Lentils (*Ervum lens*) are exported from Egypt to Europe. Vetches and other legumes are of less importance.

The commerce in beans and peas is world-wide. Among the exporting countries are Manchuria, Korea, northern China, northern India, Egypt, and Brazil. Beans are imported in large amount by Spain, Italy, France, and England.

Beans are important to the farmer not merely because of the crop itself but because the plants, in growing, extract nitrogen from the air and enrich the soil. Bacterial cultures are prepared and sold to aid farmers in thus fertilizing their land.

## STARCHES

Starches are used for food, in the laundry, in making candy, in brewing, for dressing yarns and fabrics (particularly cotton goods), in paper manufacture for filling and sizing, in making paste and adhesives, in soaps and toilet powders, as a binder in briquetting coal, etc. Even more important are the substances made from starch, such as dextrin, grape sugar, and alcohol.

When a plant lays up reserve food for future use, it often stores it in the form of starch. Frequently this starch is contained in seeds or roots for the use of the young plant in the next generation. In each plant the starch grains have a characteristic shape and size, so that it is possible to identify the different starches by means of the microscope. The process of making starch consists of grinding or grating the material which contains it and washing with water. The starch is not exactly soluble in cold water, but the starch grains mix readily with it and are easily carried off in suspension, so that the water with the starch can be strained away from the more or less fibrous pulp. The starch settles to the bottom when this milky liquid is allowed to stand for a time, and the clear water is then drawn off and the starch dried. This process varies somewhat, according to the material from which the

starch is to be extracted; wheat, for instance, is allowed to ferment slightly or is treated with caustic soda to dissolve the gluten, and maize is soaked in warm water till the grain is softened before being ground. When starch is extracted commercially on a large scale, the factories are equipped with special machinery.

**Cornstarch.** Cornstarch is manufactured chiefly in the United States and to a comparatively small extent in Europe. The chief commercial varieties are pearl, powdered, edible, crystal, laundry, confectioners', brewers', and soluble starch. It is the cheapest and most commonly used starch in this country. The starch factories are mostly in the Middle West, convenient to the corn belt. The by-product corn oil, made from the germs, is practically as valuable as the starch itself. All the other by-products—hulls, gluten, and oil-cake—go into feed for stock.

**Potato starch.** White-potato starch (*Solanum tuberosum*) is the important commercial starch in Europe. Very large quantities are made in Germany, where this industry and the potato crop bear a very close relation to each other.

**Tapioca.** Tapioca is the starch obtained from the roots of the cassava plant, also called manioc or mandioca (*Manihot utilissima*). This plant is cultivated throughout the tropics, and its roots are a common vegetable. There are two varieties, sweet cassava and bitter cassava. The latter is the more common and much the more productive variety. It contains a bitter, poisonous juice which is easily removed, however, by thorough washing and heating. Cassava meal (*farina da manioc*) and flour are much used in tropical America. Tapioca starch is manufactured in the Far East and in Brazil. It is largely exported from Singapore and Pernambuco. The grades in the market are pearl, flake, and powdered (or tapioca flour).

**Sago.** Sago is made from the starch which is stored by nature in the trunk of mature sago-palm trees (*Metroxylon* sp.). To obtain it the trees are cut down at the age of about fifteen

years, the trunks are cut in pieces, broken up, and the starch is washed out. Sago is a very important food in the Straits Settlements, the Malay States, Java, and neighboring islands. It is exported chiefly from Singapore and Java. It comes on the market usually in small rounded grains and, less commonly, as sago flour.

**Arrowroot starch.** Arrowroot starch is prepared in the West Indies from the underground stems of a plant of the ginger family (*Maranta arundinacea*). Bermuda and St. Vincent are the important producers. Arrowroot starch is particularly easy to digest and is therefore valued as a food for invalids. East Indian arrowroot is produced in India from a related plant.

**Wheat starch.** This starch is of fair importance, chiefly for food.

**Rice starch** (so called). This starch is sold in rather large quantities.

**Taro starch.** Taro starch, from the roots of a very large plant related to the "elephant-ear" (*Colocasia esculenta*), is locally important in Hawaii.

**Kumti starch** (coontie or koonti). This starch is produced from the roots of one of the cycads (*Zamia angustifolia*) in Florida.

**Sweet-potato starch, bean starch, pea starch, banana starch.** These and other kinds are produced in limited quantities.

A distinction should be made between flour and starch, but without careful examination one cannot always be sure in relation to a commercial article whether it is one or the other, for there is little actual difference between some starches prepared by washing, as described, and a flour made by grinding rice or other raw material. Of course it is not difficult to tell one from the other by microscopic examination or analysis. The following varieties of flour are worthy of mention: wheat, corn, rice, barley, milo (millet), feterita, buckwheat, potato, cassava (or tapioca), banana, soy-bean, pea. Cotton-oil meal

and other oil cakes are rich in protein, and there is occasionally an attempt to use these products in place of flour as food for humans.

### FRUITS, VEGETABLES, AND NUTS

Fresh fruits are of increasing importance as an article of commerce. This is due very largely to the fact that rapid and cheap transportation facilities by steamship and railway, often combined with cold storage, make it possible to carry fresh fruits for long distances. Apples go to Europe from New York, Oregon, Washington, and other states, and from Canada, South Africa, and Tasmania. The export of fresh fruits from South Africa has grown to large proportions, owing to the fact that apples, pears, grapes, and other fruits are ripe in the Southern Hemisphere when the supply is short in the North. Cape Colony fruit sells for high prices in Europe and the United States in the early spring. Argentina and Chile also sell fresh fruit in the North. Bananas are imported into England from the Mediterranean, the Canaries, Madeira, and the West Indies, and into the United States from Jamaica, Cuba, Central America, Panama, and Colombia. Italy, Sicily, and Spain export great quanities of oranges, lemons, grapes, and other fruits. Algeria has a large trade in fruits and fresh vegetables. California is one of the world's greatest producers of fruits, both fresh and dried.

Dried fruits, like fresh fruits, are of much larger commercial importance now than they were a quarter of a century ago. Canned fruits and vegetables, preserves, jellies, jams, fruit juices, sirups, extracts, and candied fruits are all of very large commercial value and represent great industries.

**Apples** (*Pyrus malus*). Apples are grown in New York, Michigan, Missouri, Oregon, Washington, California, and other parts of the United States, in Canada, western Europe, South Africa, Tasmania, etc. Evaporated apples (or dried apples) come largely from California and, aside from their value as

food, are of use in making wine. Apples are much used with other fruits in making jelly. Sweet cider and apple juice are bottled extensively. Apple brandy, or "applejack," was distilled from "hard" cider.

**Peaches** (*Amygdalus persica*); **pears** (*Pyrus communis*). Peaches and pears are less important than apples, owing to the fact that they do not keep so well. They are exported to Europe from South Africa and from Oregon and California in the United States. They are of much importance in local trade. There is a large sale for these fruits in glass jars and tin cans. Dried peaches are prepared in immense quantities in Delaware and California.

**Plums** (*Prunus domestica*). Plums are handled in the fresh state in rather limited quantities. Prunes are dried plums prepared in the United States (chiefly in California), in France, and in Germany. They are sold in all parts of the world. Some of the cheaper grades are used in the preparation of alcoholic liquors.

**Miscellaneous tree fruits.** Quinces (*Cydonia vulgaris*) are chiefly of value in making jelly. Quince seeds furnish a mucilage of peculiar quality. Apricots (*Prunus armeniaca*) are dried and shipped in large amounts from California and from northern India. Cherries (*Prunus avium*) are widely grown and are shipped fresh to distant points. They are also canned, preserved, and dried. Persimmons are raised chiefly in Japan and in the southern United States.

**Berries.** Raspberries (*Rubus idæus*) from southern Scotland are made into jam in English factories, as are also strawberries (*Fragaria* sp.), gooseberries (*Ribes grossularia*), etc. There is an export from England to all parts of the world of many kinds of preserves, jams, and jellies. Raspberries and loganberries (Oregon) furnish juices that are bottled and sold for drinking. Cranberries are an important crop in parts of the United States and Canada. Red currants (*Ribes rubrum*) make a popular jelly and are especially prepared in France in the form of a pre-

serve called Bar-le-duc. Blackberries, blueberries, and huckleberries are also important.

**Grapes** (*Vitis vinifera*). Grapes are among the most popular fruits and are cultivated very extensively in temperate climates.

FIG. 7. Grape Arbor in Tacna, Chile

The fruit industry is increasingly important in South America. Chile and Argentina are sending both fresh and dried fruits to the Northern Hemisphere. There are large areas well suited to the production of the fruits of the temperate climate

In many countries their chief importance is for producing wine. For table purposes grapes are grown in New York, Michigan, California, and many other states. Spain exports large amounts of white grapes (Almeria grapes). England and Belgium grow

high-priced hothouse grapes. Grape juice and grape jelly are made in large quantities in the United States.

Raisins are dried grapes (of certain varieties) and are produced chiefly in California, Spain (Malaga, Muscatel, and Valencia raisins), Greece, and Turkey (Sultana raisins). Some are produced in South Africa and Australia. California seeded raisins have a wide sale. The seeds as a by-product accumulate by the hundreds of tons and are used for the production of raisin sirup. Then they are pressed, yielding a vegetable oil suitable for food and a residue useful for cattle food and for fertilizer.

Dried currants are dried grapes of a special variety grown in parts of Greece. Dried currants are not the same fruit as fresh red or black currants. Both raisins and dried currants are fairly important in making wine.

**Oranges** (*Citrus aurantium*); **grapefruit.** Oranges are cultivated in almost all parts of the tropics and subtropics. The largest producers and shippers are Italy, Sicily, Spain, the Azores, California and Florida in the United States, Porto Rico, Jamaica, and other West Indian islands, Fiji and other places in the South Seas, southern China, and Japan. Oranges are used for making orange juice, sirup, and wine. The mandarin (*Citrus nobilis*), tangerine, navel, and blood oranges are cultivated varieties. Marmalade is prepared chiefly from the bitter orange (bigarade, or Seville orange), and the rind of this fruit is made into candied orange peel and a liqueur called curaçao. A fragrant essential oil is extracted from orange peel (largely from the bergamot orange) in France and Italy. Grapefruit (*Citrus decumana*) comes from Florida, California, and the West Indies. Shaddock and citron are related to oranges.

**Lemons** (*Citrus medica limonum*). Lemons are produced chiefly in Italy, Sicily, and California. Sicily carries on an important industry in the manufacture of concentrated lemon juice, citrate of lime and citric acid from lemon juice, and an essential oil from the rind. The candied peel of lemons and

citrons is also sold extensively. Limes are of greatest importance for the preparation of lime juice. Dominica is the largest producer.

**Bananas** (*Musa sapientum* etc.). Bananas are among the most important foods in the world. In nutritive value they surpass any other fruit in common use. There are many varieties, some of which (plantains, or cooking-bananas) are not good to eat raw. Only a few kinds will keep well enough to stand transportation from the tropics to northern markets. There is an enormous consumption of bananas throughout the tropics. The largest exporters are Costa Rica, Panama, Colombia, Jamaica, Cuba, Madeira, and the Canary Islands. Efforts have been made to popularize dried bananas, banana flour, and preserved bananas.

**Pineapples** (*Ananas sativus*). Pineapples are cultivated throughout the tropics. The principal exporters of the fresh fruit are the West Indies, the Bahamas, the Azores, and Hawaii. Florida is an important producer. Canned pineapple is sold in large quantities by Hawaii and Singapore. Pineapple juice is principally a Hawaiian product. England puts up pineapple marmalade.

**Coconuts** (*Cocos nucifera*). Coconuts are fairly important as a fresh fruit and in this state are exported from the West Indies and Central America. In the tropics the coconut is a very important food for millions of people. Shredded coconut is extensively sold.

**Minor tropical fruits.** Mangoes, alligator pears (avocados), tamarinds, and pomegranates are also exported to northern countries. Pomegranate sirup (grenadine) is extensively used in mixed drinks. Guavas make a popular jelly.

**Dates** (*Phœnix dactylifera*). Dates are the dried fruit of a palm tree which is extensively cultivated in hot, dry climates. Dates are an important export from Mesopotamia, Arabia, and North Africa, especially Algeria. Fard dates are a well-known dark-colored variety. Dates are cultivated in Arizona.

**Figs** (*Ficus carica*). This fruit is dried and exported largely from Turkey and Asia Minor. Smyrna is the chief market. Greece, Italy, and Portugal ship smaller quantities. California has become a producer within recent years.

**Olives** (*Olea europœa*). Olives are grown in all the countries bordering the Mediterranean, for food and for the extraction of oil. The chief supplies of olives for commerce come from Italy, southern France, Spain, and southern California. The pickled green fruit is more popular and is marketed in much larger quantities than are ripe olives.

**Melons.** Cantaloupes, casaba melons, watermelons, and similar fruits are extensively grown, especially in the southern United States, Colorado, and California.

**Tomatoes** (*Lycopersicum esculentum*). Tomatoes are grown in the United States more than in any other part of the world, especially in New Jersey, Maryland, and Florida. Large quantities are put up in tin cans for local sale and export. Northern Mexico exports fresh tomatoes by the trainload to the United States. Soups and table sauces (catsup), tomato paste, tomato extract, etc. are made from tomatoes. Canning and the manufacture of tomato preparations are carried on extensively in the United States and Sicily. In the region of Parma, Italy, tomato seeds are a by-product useful for making an oil of value for food and for making soap.

**Potatoes.** White potatoes, or Irish potatoes (*Solanum tuberosum*), are an extremely important food crop produced in largest quantity in northern Europe; Germany, Russia, France, and Austria grow the largest crops. Canada, New York, Minnesota, Michigan, Wisconsin, and Maine are the heaviest producers in America. Early potatoes are exported from Algeria and Egypt to France and England and from Bermuda to the United States. The international trade in potatoes is to a great extent dependent on the success or the failure of local crops. This country sometimes imports from Canada, Ireland, Germany, and Egypt. In Europe especially potatoes are a source of starch,

glucose, and industrial alcohol. Potato flour is of growing commercial importance. Sweet potatoes (*Ipomœa batatas*), yams, taro, dasheen, and other root crops are of much actual importance in the world but do not at present enter largely into general commerce.

**Garden vegetables.** Onions (*Allium cepa*) are widely grown. Texas, Bermuda, the Canaries, Spain, and Egypt produce large crops and export to other countries. Asparagus is canned in California. Cabbage, cauliflower, lettuce, celery, beets, carrots, turnips, rhubarb, green peas, fresh beans, sweet corn, artichokes, cucumbers, and many other vegetables are grown in immense quantities. Mushrooms and truffles are always on the market. Canned and dried vegetables are of continually increasing commercial importance.

**Fodder.** Hay is a very important article made by drying grass, clover, alfalfa, and the like. It is usually consumed in the same part of the world where it is produced, for, owing to its bulk, it does not pay to carry it long distances. Nevertheless there is an important international commerce in hay and other feeds for live stock and poultry.

**Walnuts.** English walnuts (*Juglans regia*) grow in California, Sicily, Italy, France (Grenoble), Chile, Turkey, etc. The whole nuts are exported, and in addition large quantities of kernels are marketed. During the World War the shells were used to make gas-mask charcoal. Black walnuts and butternuts are similar. Pecans (*Hicoria pecan*) are produced in Louisiana, Georgia, and Texas. The best are called papershell pecans. Hickory nuts (shellbarks and others) are similar.

**Almonds** (*Prunus amygdalus*). Almonds are exported from Spain (Valencia and Jordan almonds), Italy, Sicily, Greece, and Morocco (Mogador almonds). California grows a large almond crop. Sweet almonds are popular for food; bitter almonds are useful for making oil.

**Other nuts.** Chestnuts (*Castanea vulgaris*, *C. sativa*) are grown in Europe, North America, and western Asia. The

chief export is from Spain, Portugal, France, and Italy. In northern Italy chestnuts are an important food, and the poorer people use a meal made by grinding the nuts. Candied chestnuts (*marrons glacés*) are exported from France. Filberts and hazelnuts (*Corylus avellana*) are shipped from Sicily, Italy, Spain, Greece, and Turkey. Beechnuts are gathered in Europe. Brazil nuts, or cream nuts (*Bertholletia excelsa*), grow wild and are exported from the Amazon valley (Brazil) and Peru. Paradise nuts, sapucaia, or monkey-pot nuts (*Lecythis*), are from the same locality. Pili nuts come from the Philippines, cashew nuts (*Anacardium occidentale*) from northern South America, and pistachio nuts (*Pistacia vera*) from the Mediterranean, chiefly from Greece, Spain, and Sicily.

**Peanuts.** Peanuts, or ground nuts (*Arachis hypogœa*), are grown in Virginia, North Carolina, Georgia, Texas, and other Southern states. The American crop is chiefly used for food, roasted or in candy or as peanut butter. The latter is merely a paste made by grinding the nuts. Asia and Africa grow enormous crops of peanuts for the manufacture of oil. Peanut flour is made from the oil cake.

**Pine nuts** (pignoles, piñons). Pine nuts are the seeds of various species of pine (*Pinus*) and are gathered in Spain, France, and the southwestern United States. Litchis and longans are from Japan and China.

## MEAT, FISH, MILK, ETC.

Fresh meat, shipped in cold storage by steamer or railway, is a very important item in the world's commerce. Beef, mutton, and pork come from great slaughterhouses in Omaha, Kansas City, St. Louis, and Chicago. We export considerable pork to Europe and a little beef.

Argentina is the greatest exporter, sending beef and mutton in large amounts to England. Australia and New Zealand ship mutton chiefly, and there is a limited export from South Africa. Chickens, turkeys, ducks, geese, and wild fowl are shipped in

FIG. 8. Cold Storage, Sydney, Australia

New South Wales exports much frozen beef and mutton. The shallow boxes contain frozen rabbits for the English market

larger quantities and for longer distances than most persons are aware; for example, thousands of tons of poultry and game go from central China to England, and dressed turkeys are shipped commonly from Argentina. Wild rabbits are exported from New Zealand. There is a limited sale of the meat of deer, bear, and other game.

Fresh fish, oysters, crabs, lobsters, and the like are sometimes shipped long distances, though not usually. Among the most important fish are cod, mackerel, herring, sardine, salmon, haddock, halibut, hake, sole, turbot, sprat, anchovy, and sturgeon. Smoked meats (ham, bacon, etc.) and fish have a large sale.

Argentina and Brazil produce much jerked, or dried, beef (*charqui*). Dried meat scrap is an important food for poultry and stock. Dried meat is fairly important, but dried fish much more so. Cod (*Gadus callarias*) is the standard dried fish of the world. It is caught chiefly on the Grand Banks of Newfoundland, off the coast of Norway, and in the North Pacific.

Canned meats, meat extracts, meat products, fish, shellfish, and the like are immensely important. The salmon (*Oncorhynchus*) industry of Alaska, British Columbia, Puget Sound, and the Columbia River is one of the most striking examples.

Sardines, the young of the pilchard (*Clupea pilchardus*), are canned in oil on the coast of France (Brittany and the Mediterranean) and in Norway. Young herring (closely related to sardines) are canned in similar fashion in the United States, on both the Atlantic and the Pacific shore. There is an enormous trade in sardines. Canned New Zealand rabbit and canned whale meat are other important articles less often seen. Canned soups too come in this group.

Caviar is the prepared and salted roe of the sturgeon. It is made on the shores of the Caspian and Black seas, the Great Lakes, Delaware Bay, and some other places.

**Eggs.** Eggs can be stored and kept practically fresh for months, consequently there is a large international commerce;

Denmark and other European countries ship to England, and China ships fresh eggs to the United States and Europe. For industrial purposes especially, even such eggs as penguin, ostrich, and turtle are utilized when they can be gathered in quantity. There is an increasing export from China of dried egg yolk and albumen.

**Trepang.** The trepang, or *bêche de mer*, is popular in China for making soup. These sea slugs (holothurians) are captured and dried on coral reefs bordering islands adjacent to southeastern Asia.

**Seaweed gelatine, and similar substances.** Japan, or Bengal, isinglass is prepared from various seaweeds (chiefly *Gelidium* sp.). Its commercial grades are known as "gold," "silver," "confectioners'," "ice-cream," etc. Both the prepared gelatine and the natural seaweeds are used extensively. They go into foods of many kinds (jellies, ice cream, etc.) and are used for making toilet preparations to apply to the skin, for stiffening textiles, to thicken inks for printing calico, in the leather industry, for clarifying liquors, etc. Agar-agar, or kanten, is Japanese seaweed gelatine. The finest qualities are used in scientific laboratories for cultivating bacteria.

Irish moss, carrageen, dulce, and pearl moss are well-known varieties of gelatinous seaweeds, often seen in grocery stores. They are used for food and for clarifying beer. These seaweeds are gathered on the shores of the British Isles and on the coasts of Massachusetts and New Hampshire.

Iceland moss is a lichen gathered in Iceland and Norway.

Edible bird's nests come from the Malay Archipelago and the southeastern shores of Asia. They are made by certain species of swifts commonly called swallows. These nests are constructed of a gelatinous material and are highly prized by the Chinese for making soups.

**Milk.** The dairy industry is important for the production of fresh milk near many cities. Condensed milk is prepared and canned in very large amounts in New York, Illinois, and

other states. It is made in large quantities in Switzerland and on a smaller scale in Argentina and southern Brazil. The names "condensed milk," "condensed cream," "evaporated milk," "evaporated cream," are supposed to indicate something of the amount of sugar and butter fat. These articles enter extensively into international trade. Dried milk is handled as a powder and is much used by bakers. Milk and cream go into the manufacture of chocolate. Sheep's milk is used in France to make genuine Roquefort cheese. Goat's milk is commonly used in Mediterranean countries, as well as in parts of the West Indies and South America. Camel's milk is used in Africa and Asia, either fresh or in butter and cheese. Kumiss (fermented mare's milk) is imported from western Asia for medicinal purposes. A preparation of cow's milk is sold under the same name.

**Butter.** Butter is a farm product in almost all parts of the world. It is produced in large amounts in regions favorable for raising milk cattle, some of them far distant from great centers of population. Factories for making butter are usually called creameries. Butter production is important in the central United States from New York to Iowa. Butter is an export from Switzerland, Denmark, the Netherlands, Russia, Sweden, Argentina, Australia, New Zealand, and other countries. American cottonseed meal is a valuable food for milch cows and is much used in Europe. Aside from its use as food, butter is employed in dressing furs. Ghee (clarified butter) is used in very large quantities in India. Imitations of butter are made of purified animal fats (oleomargarine) and of various vegetable oils (coconut oil, cottonseed oil, etc.).

**Cheese.** Cheese is made from the milk of cows, sheep, goats, and camels. Its flavor depends greatly on the method of preparation. Large amounts are made in the United States, especially in New York, Wisconsin, Ohio, and California, in Italy, Switzerland, France, England, Germany, the Netherlands, Canada, New Zealand, and Rhodesia. It is a food high in

nutriment and is important in international trade. The most common type of cheese is the English Cheddar. Well-known varieties are Roquefort, Camembert, Edam, Limburg, Swiss, and cream.

Buttermilk contains certain ferments which have important medicinal value. Prepared tablets containing these ferments are sold by druggists. Skim milk is an excellent food for swine. Casein from skim milk is used for adhesives, for waterproof paint, for sizing paper and fabrics, for printing calico, for treating wines, and for making an article which resembles celluloid or ivory. This substance (galalith) is used for making buttons, picture frames, combs, handles, etc.

## SUGAR

**Sugar** is obtained from the juice of the sugar cane (*Saccharum officinarum*) and from the juice of the sugar beet (*Beta vulgaris*). The sugar from these two sources is identical and is not different in sweetness. Chemically this substance (whether it comes from cane or beet) is known as cane sugar to distinguish it from grape or other sugars. Two thirds of the sugar used is now derived from beets. The world consumes more sugar every year, and the percentage of beet sugar in the total production is steadily increasing. Germany, Czechoslovakia, Russia, Hungary, the United States, France, Poland, the Netherlands, Belgium, Sweden, and Italy are important beet-sugar producers. Colorado, Utah, Michigan, Nebraska, and California grow the bulk of the sugar beets in this country. Cuba, India, Java, Hawaii, Brazil, Taiwan (Formosa), Porto Rico, the Philippines, Australia, and Louisiana are the principal growers of sugar cane, although this crop is produced in practically all tropical countries. India is one of the largest producers of sugar from cane, but as a general thing the crop is almost entirely consumed at home. The chief exporters are Cuba, Java, and Hawaii for raw cane sugar, and Germany, Hungary, Poland, and Russia for raw beet sugar. The United States and Great Britain are the largest importers.

The culture of sugar cane and sugar beets has been the object of a great deal of study. Improved varieties of both plants have been developed which contain a great deal more sugar than any varieties known a hundred years ago. The enormous crops of Hawaii have been made possible by very expensive and powerful pumping stations, furnishing water for irrigation. Sugar beets are harvested with the help of special machinery, but sugar cane is still chopped down by laborers using the cutlass, or long, heavy knife. No machinery has ever been devised which will satisfactorily cut the cane in the field.

In extracting sugar from cane the fresh stalks, which contain as much as 90 per cent of juice, are crushed between powerful steel rollers. There are almost always three of these rollers set together, and there are usually three sets of rollers, so that a modern sugar mill is often referred to as a nine-roller mill. The pressing squeezes out more than 90 per cent of the juice of the cane, leaving a mass of shredded fragments called bagasse (or megasse). The juice is clarified by pumping sulphur dioxide gas through it and adding a little milk of lime, then heating and filtering it (these details vary). It is next concentrated by heating in evaporators until it becomes a thick sirup. It then goes to vacuum pans, where it is boiled at a low temperature to prevent overheating, which would burn the sugar. When the liquor has sufficiently evaporated, the sugar crystallizes and is then separated from the molasses in centrifugal machines. The molasses is reconcentrated two or three times in order to get from it as much of the crystallizable sugar as is possible. The residue is called blackstrap and is the lowest grade of molasses, suitable only for cattle food or for making alcohol. The raw sugar, produced chiefly in the tropics, is shipped to refineries, most of which are located in the United States and Europe. It is dissolved, purified, and run through filters of bone black or tripoli. Upon recrystallization it is perfectly white and appears on the market as some variety of refined sugar.

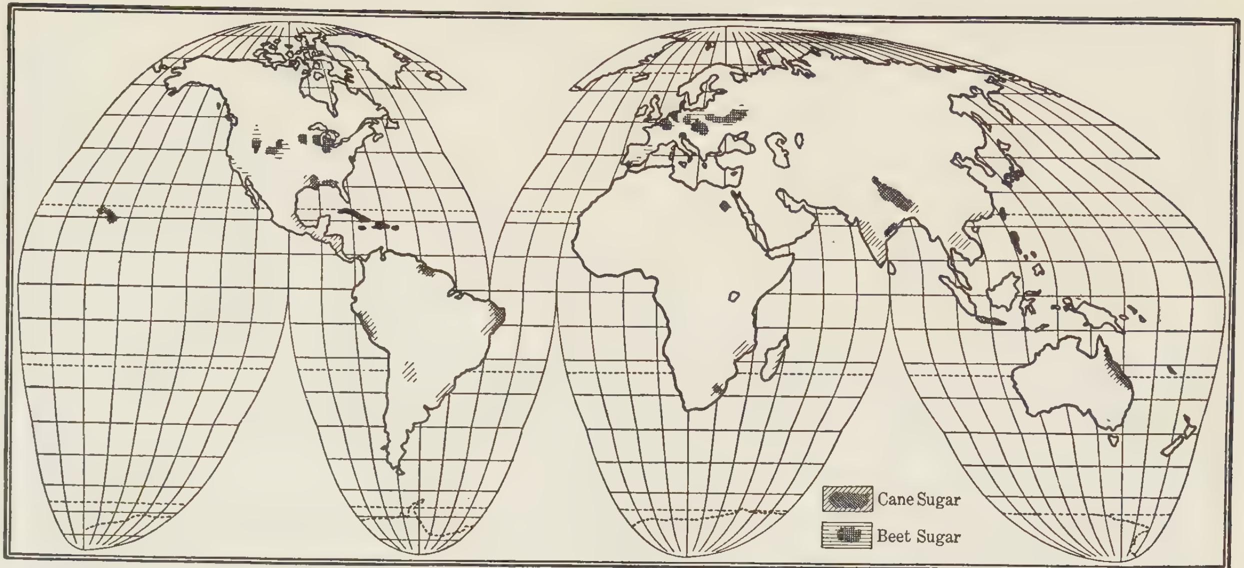
Fig. 9. A Field of Sugar Cane in Louisiana

The preceding description applies to the manufacture of modern "centrifugal" sugar and molasses. The older process, still used in many places but generally in only the regions of small production, turns out old-fashioned brown sugar, or muscovados. The evaporation of the juice is done in ordinary boilers or kettles ("open pans") and not in a vacuum. Open-pan raw sugar has a more pleasing taste than sugar from the centrifugal, and the molasses is likewise more palatable.

Sugar beets are usually cut into thin slices and then treated with warm water to extract the juice. The beet liquor is evaporated and concentrated in almost the same way as in the treatment of the juice of sugar cane. The beet-pulp residue is a valuable feed for cattle. Raw beet sugar and beet molasses both have a very unpleasant taste and are not suited for human food. Beet sugar is therefore never offered to the consumer except in the refined state.

The purity of sugar can be told with certainty by testing a standard solution by means of a polariscope, an instrument which uses a ray of a certain kind of light. This test is applied by all large sugar mills and refineries; it determines absolutely the price of any sugar as far as its purity is concerned. Commercial quotations are given on sugar under such names as "Muscovados 89° polarization," "Centrifugals 96° polarization," "Standard granulated," etc. Various grades of refined sugars on the market are known as cut, powdered, confectioners', and soft sugars of numbers from 1 to 16.

Molasses of the best quality from sugar cane is known as treacle and is used for human food. Beet molasses and the lower grades of cane molasses are used in feeding stock. They are usually mixed with bagasse, alfalfa, bran, or other feed. These preparations sometimes are sold under the name of "molassecuite" or "molasses feed." Cane sirup is prepared by merely boiling down the juice of sugar cane. Unlike molasses, no sugar has been extracted from it. Some small plantations in the West Indies manufacture nothing but cane sirup.




Goode's Homolosine Projection

FIG. 10. Areas of Cane-Sugar and Beet-Sugar Production

Previous to the nineteenth century sugar cane was almost the only source of the sugar consumed in the world. Since that time the sugar beet has become a great rival

Rum is made by fermenting and distilling molasses from sugar cane. The best rum is made from molasses from open pans. This is an important product in the West Indies. Industrial alcohol can of course be manufactured either from cane or from beet molasses.

Bagasse from sugar cane is chiefly used as fuel in the power plant which runs the machinery of the mill and furnishes steam for heating the evaporators and the vacuum pans. Bagasse is occasionally used in place of wood pulp or rags for making paper.

**Maple sugar** is obtained in the northern United States by collecting and evaporating the sap of the sugar maple (*Acer saccharum* and related species). Vermont, New York, and Pennsylvania are the chief producers. A few of the largest manufacturers have mills fitted out with vacuum pans and turn out a product of high grade. The popularity of maple sugar is due entirely to its pleasant flavor. It is chiefly used in the manufacture of confectionery and as maple sirup for table purposes.

**Palm sugar** is made in various tropical countries from the sap of the palmyra, coconut, buri, nipa, and sugar palms and other trees. It is called jaggery in India. There is a large production of palm sugar and sirup in the Far East. Palm sirup is prepared in Chile from the sap of the coquito palm (*Jubæa spectabilis*). This sirup is put up in small tin cans and sold locally under the name *miel de palma*.

**Sorghum sirup** is made in the central United States (chiefly Kentucky and Tennessee) from the juice of sorghum cane (*Andropogon sorghum*). This juice contains kinds of sugar (dextrose, glucose) different chemically from cane sugar and difficult to crystallize. The annual production of sorghum sirup amounts to tens of thousands of tons, most of it from factories equipped with modern steam evaporators. It is of merely local importance. Tennessee mountaineers refer to it as "long sweetenin'."

Fig. 11. Beet-Sugar Factory, Oxnard, California

Sugar factories using either cane or beets are naturally located in the midst of a producing area. For that reason such an establishment is commonly called a central

**Honey.** Honey is gathered by bees and is used in almost all parts of the world. Hundreds of years ago it was almost the only form in which sugar was known in Europe. At the present time it does not enter in a very large way into international commerce.

**Barley sirup.** Barley sirup (barley sugar, malt glucose, or maltose) is a kind of sugar produced during the operation of brewing. When barley or any other starchy grain is allowed to sprout and begin growing, a substance called diastase is formed. After the rootlets are removed, the malted grain is ground and mixed with warm water. In about two hours the diastase changes the starch of the grain into sugars that are known chemically as maltose and dextrose. The latter is also called grape sugar because it is found in grapes and other fruits. Fermentation will change these sugars into alcohol, and this further change is the essential part of the process of brewing beer. If the fermentation is omitted, it is possible to separate the sugars from the other ingredients and thus prepare a sirup or even a solid substance. Sometimes this process starts with a purified starch instead of barley. Maltose and dextrose are less sweet than sucrose (the sugar of cane and beet) and do not so easily form crystals. Nevertheless barley sirup is a useful substance commercially and is prepared for sale by some brewers. It is used by bakers, manufacturers of candy, canners, and makers of soft drinks. Some brewers prepare a special sirup low in sugar but high in diastase which is of use medicinally and in laundries for cleansing starched clothing. This same substance has been prepared in Japan for hundreds of years under the name of *amé.* The Japanese make it in both solid and liquid forms and think that for some purposes it is superior to cane sugar.

**Glucose.** Commercial glucose is a sweet, thick, almost colorless liquid prepared by treating starch with weak hydrochloric acid. In America cornstarch (making corn sirup) and in Europe potato starch (making potato sirup) are the bases used.

Corn sirup does not crystallize readily, and consists chemically of a mixture of dextrose and maltose with dextrin. It is mixed with cane sirup and molasses to make sirups for the table or for cooking; it is used for making candies, jellies, and preserves; for baking and cooking; for flavoring chewing-tobacco; in brewing beer; in the preparation of pastes, sizes, extracts, inks, polishes, liquid soaps, etc.; for filling leather; for mixing in the composition to make printers' rollers; in finishing molds and cores in iron foundries, in silvering glass for mirrors, in preparing sponges and coffee, and in polishing rice. There are two principal commercial grades: mixing-sirup and white-corn sirup. "Corn sirup" is a name which is in many ways preferable to "glucose." Other names are "starch sirup," "cereal sirup," "confectioners' sirup," "crystal sirup," "sirup of gum," and "tanners' sirup." Corn sirup and corn sugars are made in several large factories in the United States, mostly in the Middle West. Germany, France, and England all manufacture potato sirup.

**Grape sugar.** Grape sugar (corn sugar or solid glucose) is a compact, more or less waxy, sticky substance nearly white in color. It is prepared, like corn sirup, by treating starch with weak hydrochloric acid, but the process is continued for a longer time, till most of the dextrin is changed into dextrose. "70 sugar" is composed of 86 parts of dextrose to 14 of dextrin; "80 sugar" contains 92 parts of dextrose with only 8 of dextrin. Anhydrous sugar contains 98 per cent of dextrose. Climax sugar is mostly used by brewers. Bread sugar is a very pure product. Corn sugar is used in brewing, for filling leather, for making caramel, etc.

**Sugar of milk.** Sugar of milk is produced from whey, a by-product in making cheese. It is used in medicine and in the process of silvering mirrors.

See Manna and Saccharine.

**Caramel.** Caramel is a soluble substance produced by carefully heating sugar (cane sugar or grape sugar). Its chief use is for coloring rum, whisky, and wines.

## SPICES, CONDIMENTS, AND FLAVORS

Salt is, of course, the most important substance in this group (see page 247). Many spices owe their fragrance and often their peculiar taste to an essential oil. Flavors, however, are varied, and their taste is due to a great many different things. Hundreds of substances with distinctive tastes are used in one way or another for flavoring. Among the things not described in detail under this head are fruit sirups and extracts, tea, coffee, maple sirup, pistachio and other nuts, aloes, asafetida, sarsaparilla, etc., and many essential oils. Many flavors are developed by fermentation or bacterial growth, as in the case of black tea, alcoholic liquor, yeast, etc. Artificial flavors are made in chemical laboratories, mostly from a coal-tar base; these reproduce almost perfectly the taste of vanilla, cinnamon, and other spices, as well as fruits such as apple, peach, cherry, etc.

**Mustard.** Mustard is the most commonly used spice. It is the seed of several plants (*Brassica* or *Sinapis* sp.) cultivated in England, the Netherlands, Germany, Austria, Italy, North Africa, Asia Minor, Mesopotamia, Russia, India, and China. California and Kentucky in this country grow mustard for the market. The seeds are of two types, brown and yellow, although they are sometimes black, red, or white in color.

Mustard seeds contain so much oil that they are not easy to grind into a fine powder. It is therefore usual to press the seeds first and extract about 20 per cent of mustard oil, a bland and practically tasteless oil suitable for table use. The mass is next put through a grinding mill and is then sifted into ground mustard of different qualities. When powdered brown mustard is mixed with cold water, a fragrant essential oil is developed which gives the well-known sharp odor and some of the taste to prepared mustard, and causes a burning sensation when applied to the skin (in mustard plasters). Yellow mustard does not form this essential oil but contains a sharp-tasting, acrid substance which is the cause of much of the taste of prepared

mustard. The best mustard on the market, therefore, is composed of a mixture of the flour of both the brown and the yellow varieties. Common adulterants are wheat flour, turmeric, and red pepper. Trieste mustard comes largely from northern Italy. The mixture sold in bottles under the name "French mustard" is composed of crushed mustard seed and vinegar. The poorer qualities are made of mustard bran, or the low grades of mustard flour.

**Pepper.** Black pepper, one of the commonest spices, is the fruit of a vine (*Piper nigrum*). It comes from the region of Singapore on the Malay Peninsula and from neighboring islands, from Sumatra, Java, and others of the Dutch East Indies, the Malabar coast of southern India, Siam, and Indo-China. The berries are gathered when they begin to turn red. They are picked, cleaned, and then dried for several days on mats in the sun, or in bamboo baskets before a gentle fire. The pulp shrivels and turns black in drying.

White pepper is prepared from the fully ripened berries, which are bruised and washed free from the pulp before they are dried. Some white pepper is prepared in the Far East and in Europe by soaking black-pepper berries and then removing the outer coat by rubbing.

Commercial varieties of black pepper are known from the district of production or the port of shipment as Singapore, Johore, Sumatra (Achin, Penang, and Lampong), Java, Malabar (Tellicherry and Aleppy), Siam, and Saigon. Shot, or heavy, pepper is free from hulls and light berries. The wholesale markets for pepper are Havre, London, and Amsterdam.

Long pepper is the fruit of a similar vine (*Piper longum*). It is cheaper than true black pepper and is used chiefly in pickling or for adulterating ground pepper. Cubebs (*Piper cubeba*), from Java, are used in medicine.

Red pepper (or cayenne pepper) is the fruit of a plant (*Capsicum* sp.) which is cultivated throughout the civilized world. In Spanish-speaking countries it is known as chilies.

There are several species, and many varieties with fruits of varying size up to five or six inches in length. Some of the small kinds have the hottest flavor. Red peppers are grouped in three classes: chilies, capsicums, and peprikas. Chilies are small fruits which when ground are called cayenne. Capsicums when ground are called red pepper. Some varieties of capsicum are classed as sweet peppers and are used as garden vegetables.

FIG. 12. Sorting Chilies in Osaka, Japan

The unbroken pods are separated from the damaged ones by cheap hand labor

There are two varieties of peprikas, hot and sweet. When ground to a fine powder, peprika is called paprika.

Chilies come principally from Zanzibar, Mombasa, East Africa, and Japan. Smaller supplies come from Sierra Leone, Nyasaland, Nepal, Java, South America, and Europe. Capsicums come from Mexico, East Africa, and India, and (in the United States) from California. Paprika is usually imported from Hungary or Spain, ground ready for use.

The names "pimenta," "pimienta," and "pimento" are commonly applied to peppers and other spices.

**Allspice** (Jamaica pepper or pimento). Allspice is the dried unripe fruit of a tree (*Pimenta officinalis*) which is cultivated chiefly in Jamaica. It is gathered by breaking off twigs which bear bunches of the berries and drying them in the sun.

**Cloves.** Cloves are the dried unopened flower buds of a tree (*Eugenia caryophyllata*). They are cultivated chiefly in Zanzibar and the neighboring island of Pemba and in two small islands, Penang and Amboina, near the Malay Peninsula. Smaller supplies come from Sumatra, Java, and various islands in the region of the Molucca Passage, as well as Ceylon, the island of Réunion, and the West Indies. The best cloves are picked by hand and dried carefully over a fire. Large quantities are shaken from the trees onto cloths spread beneath and are dried in the sun. Cloves are used in enormous amounts in India and in the Far East. The greatest importers are Bombay, London, Amsterdam, Hamburg, and New York.

Cloves are used for flavoring food, confectionery, and liquors. One of their virtues is that they prevent decay of food as well as flavor it. Clove stems, or clove stalks, are the short stems on which the cloves grow. Mother cloves are the ripe fruits of the tree. Like the stems, they have a weaker flavor than true cloves, but are used to some extent as a spice. Clove oil is distilled chiefly from the stems and mother cloves.

**Nutmegs.** Nutmegs are the kernels of the fruit of a small tree (*Myristica fragrans*) which is cultivated in the East Indies. The chief plantations are in the Banda Islands, Penang, Java (Batavia), Amboina, Zanzibar, and Réunion. Nutmegs are raised also in Grenada and Jamaica in the West Indies. Inferior grades of nutmegs are often coated with lime. Nutmegs are classified for sale according to size; the numbers, 60's to 130's, indicate the number of seeds to the pound.

There are many kinds of inferior nutmegs and mace which occasionally come on the market, such as Makassar wild, male or long, nutmeg from Celebes and neighboring islands, Papua, Brazilian, Madagascar (or clove nutmeg), Bombay, etc.

**Mace.** Mace is the lacelike seed coat (*arillus*) which covers the shell of the nutmeg. It is bright red when fresh, but turns yellow on drying. Singapore nutmegs and mace are produced in the islands of the region, but are graded, packed, and shipped from that city. West Indian nutmegs and mace are weaker in flavor than those from the East.

**Ginger.** Ginger consists of the dried root stalks of the ginger plant (*Zingiber officinale*). It is found in commerce in two classes: "coated" and "uncoated." Coated (black) ginger is produced by drying the green roots in the sun; uncoated (white or peeled) ginger has been washed or scraped and sometimes actually peeled before being dried and is usually bleached and covered with lime. Jamaica ginger is in the peeled class and is the best quality on the market. Jamaica ginger of the drug stores is an alcoholic extract of gingerroot. African ginger is mostly coated ginger and comes from Sierra Leone. Cochin ginger of the trade is grown in southern China, Cochin China, and on the Malabar coast of southern India. Borneo is only a trade name for ginger. It is not from that island. Calcutta (race or calient) ginger is from northeastern India. Japan ginger is less pungent than almost any other variety.

Ginger is used as a flavoring and stimulant in foods and in drinks, such as ginger ale. It is often preserved in sirup (Canton preserved ginger) or candied for use as a sweetmeat.

**Turmeric.** Turmeric consists of the underground stems of a plant of the ginger family (*Curcuma longa*). It is grown in southeastern Asia and the neighboring islands. The chief exports are from Madras and Bengal. It is an important condiment used in curry powder. In solution it gives a beautiful yellow dye for cotton goods. Tanners use turmeric in preparing fancy leathers, and chemists use paper colored with it in testing for alkalies and for boric acid.

**Galangal and zedoary.** These are spices used in the East.

**Cinnamon.** Cinnamon is strictly the dried bark from the young shoots of a tree (*Cinnamomum zeylanicum*) which is

cultivated in Ceylon. It comes to market in bundles ("rolls") composed of long rods, or "pipes," made of thin quills of bark thrust one over another. "Chips" are the broken fragments of bark that could not be made up into pipes, and are a cheaper grade. Most of the Ceylon crop goes to England. The tree has been introduced into many tropical countries, but there is no important production of commercial cinnamon bark elsewhere.

FIG. 13. Peeling Cinnamon in Ceylon

The spicy bark is carefully peeled from the rather small, young branches. After drying, it is formed into long sticks or quills, a style of packing which perpetuates the form in vogue a thousand years ago

**Cassia bark** (or cassia cinnamon). Cassia bark has a flavor said by some persons to be identical with cinnamon, although of course the lower grades of cassia are inferior to good Ceylon cinnamon. Cassia bark is almost always thicker and coarser than cinnamon. It comes on the market under such names as "Chinese cassia," "cassia lignea," "cassia vera," etc. and is said to be from several species (*Cinnamomum cassia* etc.). The best grade is Saigon cassia from Indo-China. Saigon, Kwangsi, and

Chinese cassia (from various parts of southern China) are shipped from Canton and Hongkong. Batavia, Corintje, Preanger, and Java cassia are from the Dutch East Indies. Japan and the Seychelles produce little cassia.

Cassia buds are the dried unripe fruits of the cassia tree. These and cassia twigs are exported in limited quantities from Canton. Cassia oil is distilled from chips, twigs, leaves, and bark. It is used for flavoring and perfumery.

**Vanilla.** Vanilla is the prepared unripe fruit of a kind of orchid (*Vanilla planifolia*). The best quality of vanilla beans comes from the state of Vera Cruz, Mexico, where the plant is native. The Mexican "beans" are dried very slowly, and during the drying are sweated several times, which causes them to ferment slightly. The process is carried on by skilled persons, and this careful curing develops the vanilla flavor. Inferior beans or those that do not present a fine appearance are cut into short pieces and sold as "cuts"; some crack lengthwise and are called splits.

Vanilla is cultivated in the hot, moist valleys of various tropical islands. Bourbon vanilla comes from the Comoro Islands, Madagascar, Réunion (Bourbon), the Seychelles, and Mauritius. Tahiti vanilla is a cheap grade produced in large quantities in the south Pacific. Bourbon and Tahiti vanillas are cured much more rapidly than are Mexican beans. The fresh green pods are dropped repeatedly in hot water, are then stored carefully for a period of sweating or fermentation, and are finally dried by artificial heat, sometimes with the aid of calcium chloride to absorb the moisture. Some judges say that Tahiti vanilla has not the true aroma but smells like heliotrope. A relatively small crop of vanilla is produced in Guadeloupe and some others of the West Indian Islands, and a very little in Brazil. This latter is usually in large pods of inferior quality.

Vanilla is used for flavoring chocolate, ice cream, cakes, candies, etc. The poorer grades are used extensively to flavor chewing-tobacco and to scent sachet powder.

After curing, vanilla pods are often more or less covered with a fine white crystalline powder. This is called vanillin and is the principal and most important ingredient in vanilla flavor. In itself, however, it does not contain all that is in the smell and taste of high-grade vanilla beans. The name "vanillon" is applied in the trade to cured vanilla of inferior quality and usually to beans of small size. It is said that Mexican vanillon is from another species of orchid (*Vanilla pompona*). Vanillon, or vanillin, is a substitute for vanilla made usually from oil of cloves (eugenol) or sometimes from a coal-tar base. It has been prepared from a juicy substance found in fresh hemlock bark. Vanillon of this kind is generally in small white crystals.

Tonka beans are from a large tree (*Dipteryx odorata*) which grows wild in Venezuela, Guiana, and Brazil. They contain an aromatic substance, coumarin, which resembles vanillin. This is also prepared artificially. Cheap vanillas have made it unprofitable to market these seeds in quantity.

**Cardamoms.** There are several varieties (*Amomum cardamomum* or *Elettaria* sp.) from Ceylon and the Malabar coast of India. They are used in pickling and in curry powder. Paradise seed (grains of Paradise, melegueta or malagueta pepper), of Africa, is related.

**Coriander** (*Coriandrum sativum*). Coriander is grown in Russia and in Mediterranean countries. It is used in pickling, in sausage-making, and in medicine.

**Various seeds.** Caraway seed (*Carum carvi*) comes from Germany, Holland, Austria, and Sweden. It is used in rye bread, in pickling and sausage-making, in distilled liquors, medicine, and perfumery. Anise seed (*Pimpinella anisum*) is grown in Spain (Alicante), southern Russia, and Germany. Star anise is from China and Singapore. Celery seed (*Apium graveolens*) comes from France. Dill seed (*Anethum graveolens*) is from southeastern Europe and southwestern Asia. Cumin seed (*Cuminum cyminum*) is mostly from Malta. Fen-

nel seed (*Fœniculum fœniculum*) comes from France, Germany, Russia, and Mediterranean countries. Fenugreek, fœnugreek (*Trigonella fœnumgræcum*), is from the Mediterranean. Sesame (*Sesamum indicum*) from India and the Mediterranean, beni seed from Africa, poppy seed, and rapeseed (*Brassica* sp.) are more important as oil seeds.

**Licorice root.** Licorice root, or liquorice, is from a plant (*Glycyrrhiza glabra*) which grows wild in countries bordering the eastern Mediterranean and is cultivated in Spain. Supplies come from Spain, southern France, southern Russia, and Asia Minor. Black stick licorice, or licorice paste (Spanish or Italian), is a solid extract made by boiling the root and then sweetening and evaporating the liquid. Licorice is used for flavoring tobacco, candy, and liquors and in medicine.

**Capers.** Capers are the flower buds of a plant (*Capparis spinosa*) which grows wild in Mediterranean countries. They are put up in salt water or in vinegar. Most of the import to the United States is from France and Spain. Italy and Algeria are also producers.

**Saffron.** This is the dried stigma of a bulbous plant (*Crocus sativus*) cultivated in Austria, France, Spain, and the Near East. It is used for flavoring and coloring food and to a small extent in dyeing fabrics.

**Various leaves.** The leaves of various plants are used for flavoring. Among the important kinds are bay leaves (*Laurus nobilis*), from Greece and Asia Minor; marjoram, from France and Germany; sage, from Austria, Italy, France, Greece, and Mexico; savory, from Austria; thyme, from southern Europe; and tarragon, from Europe. Mint is of two kinds: peppermint (*Mentha piperita*) and spearmint (*Mentha viridis*). Both are used for flavoring, but are of more importance for the production of essential oils.

Horseradish root, garlic, parsley, water cress, and many other substances are used for flavoring.

**Shoyu.** *Shoyu*, or soy sauce, is a popular table sauce in Japan and China. It is prepared by fermenting soy beans and mixing them with salt water and other ingredients.

**Vinegar.** Vinegar is a fermentation product resulting from a chemical change in some alcoholic liquid. In the United States cider vinegar is the kind most commonly used. The other types are wine vinegar and malt vinegar, each of course with its distinctive flavor. Vinegar is used as a table condiment and preservative. Its essential constituent is acetic acid, a chemical commonly obtained in wood distillation and hence referred to as "wood vinegar."

# BEVERAGES

**Tea.** Tea is prepared by carefully drying the leaves of the tea plant (*Thea sinensis*). The exporting countries are British India, China, Ceylon, Japan, Taiwan (Formosa), and Java. Tea is grown in Natal, in the Caucasian republics, in Burma, Jamaica, Brazil, and Fiji, but the product is relatively small, and most of it is consumed locally. There is a very large consumption of tea in China and Japan. The principal importers are the United Kingdom, the United States, the Netherlands, and British colonies. There is an important overland trade in tea from China to Tibet and Russia (caravan tea) and from Assam to Tibet and Persia. The United States has been the chief importer of green tea, chiefly from Japan. The recent tendency in this country is toward the use of black teas, which are imported in increasing quantity from Ceylon.

Tea plants are grown, generally on hillsides, in a region extending from the tropics to fairly cool parts of China and Japan. In Ceylon and Java, where there is no winter, tea leaves are picked, sometimes every ten days, throughout much of the year. Farther north four or five pickings are taken annually, and on the most northern plantations the leaves are gathered only once or twice a year. The climate, of course, determines the growth of the plant and governs the amount of picking which is possible.

The young leaves of the tea plant, like those of most other plants, have a more pleasant taste than the old leaves, and hence it is only the young leaves that are gathered to make tea. The sweet, tender leaves are produced on fresh shoots that branch out from older stems on the plant. These rapidly growing shoots are called flushes by the growers of tea. When the flush is a few inches long and has six or seven leaves, it is ready to be picked. When it is gathered, it is usual to break off the

little stem with about five leaves and the young unopened leaf bud at the tip, leaving on the plant the remainder of the flush, with one or two leaves. The process of preparing tea from the fresh leaves varies greatly in different places. China still uses hand labor almost entirely; in Ceylon almost every operation is done by machinery. The flavor and quality of tea depend on the soil and climate, the age of the leaf, the time of picking, and the process of preparation. In general, tea of the finest quality is produced from the youngest leaves or the leaf buds and from the first picking of the season. The most costly teas used by rich Chinese are those prepared by picking only the youngest leaves or the tip leaf buds and drying them in the most careful manner.

FIG. 14. Picking Tea in Ceylon

The girl is carefully breaking off the "flush," or tender green tip, consisting of the unopened leaf bud and two or three young leaves. Her worldly wealth consists of silver necklaces, bracelets, armlets, earrings, finger rings, and toe rings

The commercial processes may in general be described as follows: After picking, the leaves are withered on trays or shelves in sheds (rarely in the sun) and usually by artificial heat, either over a fire or over steam. The next operation is rolling. This curls up the leaves and in some processes presses out a little of the juice. When the rolling is done in a machine, it is followed by roll-breaking, which loosens up the lumps that

have been formed and separates the twisted leaves from one another. If black tea is being made, the next operation is fermenting, which means that the leaves are covered up and kept sufficiently warm to cause them to lose their green color in a few hours. If they remained in this condition too long, they would actually decay, but the fermentation is stopped when it has gone far enough. The length of time depends on the temperature and on the judgment of the person in charge. The flavor of the tea is governed largely by the amount of fermentation. Next the tea is dried, or "fired," sometimes in a large machine by a current of hot air, sometimes on bamboo trays over a charcoal fire or in copper pans, or very rarely by the heat of the sun. The third process, fermenting, is omitted when green tea is made, and the leaf therefore retains more or less of the natural color when it dries. Oolong tea is fermented only a short time, so that it is intermediate between green tea and black tea.

After firing, the dried tea is sifted to separate the large leaves from the smaller ones. Black tea is thus sorted into "golden tips," the youngest buds; "orange pekoe," the smallest leaf; "pekoe," the second leaf; "pekoe-souchong," the third leaf; "souchong," the fourth leaf; and "congou" (sometimes called "bohea"), the fifth and usually the largest leaf gathered. In addition there is always more or less "dust" and "broken," which are inferior grades. "Caper" is a fancy grade of black tea in little pellets.

Green teas are similarly sifted, giving "gunpowder," in little balls; "imperial," in large balls; "young hyson"; "hyson No. 1"; and "hyson No. 2." The hyson teas are twisted leaves instead of small pellets or balls.

All these teas, both black and green, are further classified according to quality and flavor by such names as "fancy," "choice," "fine," "medium," "superior," "good," "fair," "common," and "standard" or by numbers 1, 2, 3, 4, 5. There is a tendency to use the term "uncolored tea" instead of "green

tea." In past years green teas were often artificially colored by means of prussian blue and other dyes, but this practice has been discontinued.

Scented teas are dried with various fragrant flowers to give them a pleasing aroma. The dried flowers are later sifted out. Pouchong tea is put up in small packages and is often scented. "English breakfast" is an American name for a popular flavor; the tea so called is usually a Chinese congou tea. Teas are further named according to the method of preparation as "pan-fired," "basket-fired," "sun-dried," etc., and according to the district of production as Japan, Formosa, Ceylon, China, India, Assam, etc. Japan produces mostly green tea; China, both green and black tea; and India and Ceylon, mostly black tea.

Tea is prepared by machinery in large factories, so that it can at once be packed for export. In Japan and China, however, enormous quantities of tea are prepared on small farms where all the work is done by hand. All such tea must be re-fired and more thoroughly dried before it is packed in tea chests for shipment. It comes into commerce packed chiefly in light wooden boxes lined with lead or zinc to protect the tea from air and moisture, or sometimes in small packages lined with metal foil. The teas which are sold in our stores are often mixed, or blended, from several different varieties to please the taste of the customer. Skillful blending can be done only by an experienced man, able to judge delicate flavors which are scarcely apparent to the ordinary person. When tea leaves are put in hot water the stimulating element (theine) that they contain dissolves readily, together with other constituents which give to the drink its taste and aroma. The leaves contain tannin also, which dissolves out if they remain long in hot water.

Brick tea is prepared by pressing broken leaves, twigs, and dust into blocks, which are sometimes held together by the addition of a little rice paste. It is of several qualities and is exported chiefly from China to Tibet and Russia. Tablet tea is similar. Tea extract, or soluble tea, is on the market.

**Maté.** Maté, yerba maté, herva maté, or Paraguay tea consists of the dried leaves and twigs of a small holly tree (*Ilex paraguayensis*) which grows wild in southern Brazil, Paraguay, and the adjacent part of Argentina. In collecting maté branches of fair size are cut from the trees and dried over a fire, and then the leaves and small twigs are pounded to a coarse powder. Some grades of maté consist of broken leaves only, but the kind with twigs in it is generally considered the best. The natives often pack it in bags made of the skins of freshly killed cattle. There are large factories in southern Brazil where maté is packed in kegs and tin cans for shipment and sale. With hot water maté makes a drink similar to tea. The popular way of preparing it is to put the dried leaves and the hot water in a gourd instead of a cup and to drink it through a *bombilla*, a tube with a strainer at the lower end.

Maté is very popular in southern Brazil, Argentina, Paraguay, Uruguay, Bolivia, and part of Chile. It contains caffeine and is therefore stimulating like coffee and tea. Some persons claim that it has no harmful effects.

There is a small export to Europe and North America, where it is used in preparing soft drinks.

**Guaraná.** Guaraná is prepared from the seeds of a tree (*Paullinia cupana*) which grows wild in the Maués district of the Amazon Valley, Brazil. The seeds are ground up with water and manioc flour into a paste, which is molded into round sticks or made into small figures resembling fruits and animals. For use, the preparation is grated and the powder is mixed with water to make a drink. It contains caffeine and so has the same stimulating effect as tea and coffee. It is used locally, and small amounts are exported for medicinal purposes. In Brazil it is employed in preparing an aërated beverage.

**Coffee.** Coffee is the seed of a shrub or small tree (*Coffea arabica*, *C. liberica*) which is usually kept trimmed to a height of eight or ten feet for convenience in picking. Aside from Arabian and Liberian coffees, the two typical species, there are

two or three other species and many cultivated varieties. Among the most important of these is Maragogipe coffee, which has a bean even larger than the Liberian species. The berries when ripe are red in color, about the size of a cherry, and grow thickly clustered along the branches. They contain two seeds, each covered by a thin membrane (silver skin), then by a thick, tough skin (parchment), the whole being inclosed in a pulp which holds the two "beans" with their flat sides together. Some berries growing on the same plant as the others contain but one bean, which is round instead of flat and is called pea-berry, pearl, or male-berry coffee.

After picking there are two ways of preparing coffee for market: the dry and the wet method. The dry method is much used in Brazil and in many other parts of the world. The red berries are carried directly to drying-floors and spread out in the sun. They remain there for two or three weeks, being raked over from time to time to expose all the berries and cause them to dry uniformly. Of course they must be protected from rain by means of canvas covers, movable roofs, etc. Sometimes the drying is done in machines heated by hot air or steam, especially if the weather is unfavorable. The dried berries are run through machines which break and clean away the dried skins and pulp from the beans. When a plantation uses the wet method (West Indian process), the freshly picked berries are run through a pulping-machine, which crushes them and washes away the red skin with some of the pulp. But a great deal of the flesh of the berry sticks to the beans, and so the coffee is put in large tanks, where it lies till the sweet, wet pulp begins to decay very slightly. This process is called fermenting. Next, the softened pulp is washed away, and the beans are spread out on cement floors to dry in the sun, or, less commonly, they are dried by artificial heat. They are still covered with the parchment skin, which is tough while it is wet but becomes brittle on drying. Cleaning-machines break and fan away the parchment and the silver skin and then polish the beans, making them ready for market.

Nearly three quarters of all the coffee produced in the world is raised in the highlands of Brazil, in a region which, while it covers thousands of square miles, looks on the map like only a small part of Brazil. It lies back from Rio de Janeiro and north from the city of São Paulo. Santos is the chief shipping port. Other important coffee producers are Venezuela, Colombia, Central America (especially Guatemala and Salvador), Mexico, Haiti, Jamaica, Porto Rico, Java and neighboring East Indies, Arabia, and Abyssinia. Smaller amounts are gathered in India, Ceylon, Queensland, Natal, central Africa, Liberia, Hawaii, Paraguay, Peru, Bolivia, and Ecuador. The chief importing countries are the United States, Germany, France, the Netherlands, Great Britain, and Italy. Turkey also is a great user of coffee. The chief markets in the United States are New York and New Orleans; in Europe the chief markets are London, Havre, and Hamburg.

Coffee is exported in burlap bags weighing usually one hundred and thirty-two pounds, under the name of the producing locality or place of export. The two principal types of Brazilian coffee are Rio and Santos. Venezuela ships Maracaibo and La Guaira, with many varieties such as Caracas, Coro, etc. The term "Government Java" is applied to coffee from plantations operated on that island under government supervision. Mocha coffee comes from Arabia and Abyssinia, although the latter is often sold under its own name. Coffee is graded according to its color—brown, yellow, pale, blue, gray, green, etc.—and according to the size and shape of the bean. Brazilian grades are called by numbers 1, 2, 3, 4, 5, and so on. A typical quotation would be on "Rio Standard No. 7." The round beans are usually sold by themselves and bring a trifle higher price than a similar quality in a flat bean. Coffee in the parchment improves with age (for a few years) if properly stored; therefore Old Government Java was a highly prized coffee. The law in the United States forbids selling coffee under a false name. Therefore it is illegal to call a coffee Mocha unless it is of a

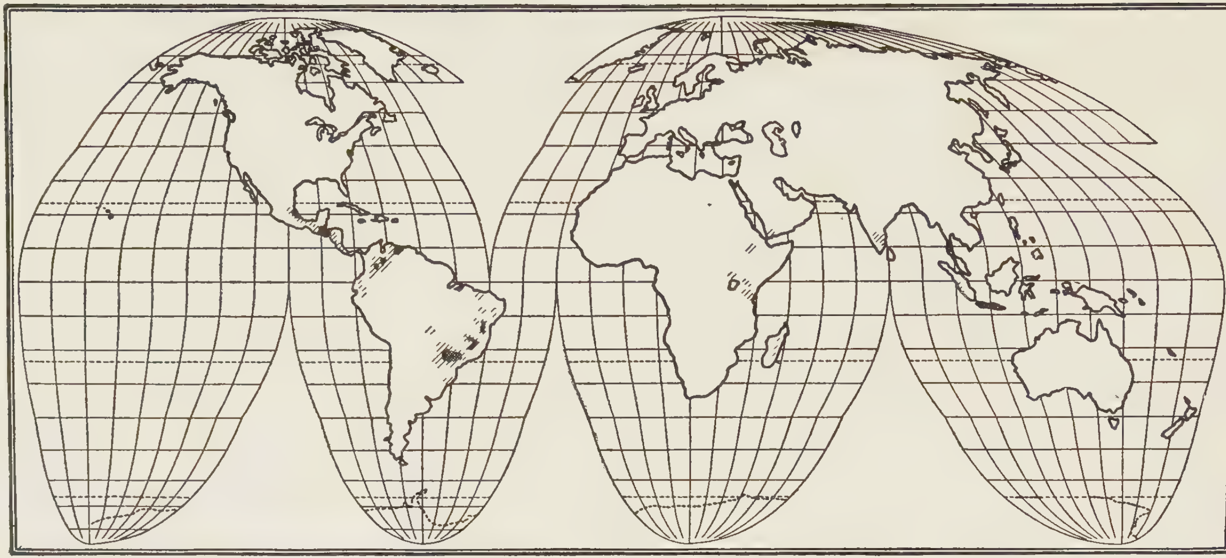



Fig. 15. Areas of Coffee Production

For many years Brazil has led the world in growing coffee. Venezuela, Colombia, and other countries are rapidly increasing their output

certain standard type and did actually grow in the part of the world near that city. Before the law was passed, a great deal of Brazilian coffee was sold under the name of Mocha.

Coffee extract, coffee essence, or soluble coffee is put up for sale in order to make it easy to prepare the beverage. Coffee contains an alkaloid, caffeine, which has decidedly stimulating qualities. The characteristic flavor is developed by roasting the beans, usually within a comparatively short time before the coffee is to be used. Coffee experts mix different kinds of beans for the purpose of putting on the market a brand of coffee which will have a flavor that will please the buyer. Blending coffee is a business which requires long experience and careful judgment. There is said to be little adulteration in ground coffee at present.

**Chicory.** Chicory roots when roasted and ground are used as a substitute or as an adulterant for coffee. Some persons find coffee harmful and prefer to use chicory or some other substance, such as roasted barley or wheat, to make a drink, since these things do not contain caffeine, the stimulating principle found in coffee, tea, and chocolate. The chicory plant (*Cichorium intybus*) has a pale-blue flower and is a common weed along roadsides. Much of the chicory used is imported from Belgium, Germany, and France. It is cultivated also in Michigan, and there are several factories for its preparation in the United States.

**Chocolate; cocoa.** Chocolate and cocoa are prepared from cacao beans. The fruits of the cacao tree (*Theobroma cacao*) are from six to ten inches in length, with thick leathery rinds, and each fruit contains thirty or more seeds usually called beans. These fruits grow on small trees and are attached by short stems directly to the trunk or the large branches. In some places the seeds, after removal from the pods, are prepared by simply drying in the sun. These are called unfermented beans. In most producing countries the seeds covered with soft sweet pulp, just as they come from the pods, are piled in large boxes

Fig. 16. Picking Coffee in Campinas, Brazil

The coffee country of the state of São Paulo is wonderful farm land. Rolling hills are covered with seemingly endless rows of coffee bushes. The heavy red berries are pulled off, gathered up from the ground, and winnowed to remove leaves and dirt before they go to the drying-floors

or bins until the pulp ferments, softens, and can be easily removed. Many persons believe that this fermentation of the pulp causes the best flavor and aroma to develop in the bean. Both unfermented and fermented (or rotted) beans are used extensively by manufacturers. In Ceylon the beans are washed after fermentation to remove all the pulp, so that they come to market bright and clean. After fermentation they are dried, usually in the sun, on wooden floors, and generally there are sliding roofs or other arrangements by which the cacao can be protected in case of rain. In parts of Venezuela the beans are sprinkled with red earth, which helps to absorb the moisture, and some of this earth sticks to the skin of the bean held by the dried pulp. These are called clayed beans. Often considerable dried pulp adheres to the beans. In Trinidad the appearance of the cacao is improved by piling the beans up in heaps and allowing barefooted men to jump up and down in the pile, rubbing the beans together and thus loosening some of the dried pulp. This is called "dancing the beans."

Brazil and Ecuador are the largest producers of cacao. Very large quantities are grown on the island of Sao Thomé in the Gulf of Guinea and on the adjacent mainland of Africa, especially on the Gold Coast. Venezuela, Colombia, Trinidad, Guiana, Central America, southern Mexico, various West Indian islands, Ceylon, and some of the East Indies are producers. All these regions are warm and moist and situated within less than twenty degrees of the equator. Commercial grades are named from the countries of production or from the ports of shipment; as, Accra, Bahia, Guayaquil, Maracaibo, Trinidad, Haiti, etc. The chief wholesale markets and greatest importers are Hamburg, New York, Havre, and London.

In the process of manufacture cacao beans are cleaned and then carefully roasted. The flavor depends greatly on the roasting as well as on the original quality of the bean. Next they are crushed. The thin shells are winnowed out, leaving the fragments of beans, known commercially as cocoa nibs.

FIG. 17. Gathering Cacao in Grenada, West Indies

The heavy pods grow on the trunk or large branches of the trees. The ripe fruit is rich red, bright yellow, green, purple, or brownish on different cultivated varieties of the tree

Bitter chocolate is made by grinding cocoa nibs to a fine smooth paste which is molded into cakes. Sugar is added to make sweet chocolate, which is often flavored with vanilla or cinnamon. It is used in very large amounts by makers of candy, who frequently mix it with almonds or other nuts. Large quantities of milk are used by manufacturers of milk chocolate, and this is so important that chocolate factories are often located in farming regions where the milk supply can be depended on; for example, the factories in Switzerland and in Pennsylvania. A little chocolate is used by some factories for flavoring cigarettes. Pure chocolate (bitter chocolate or cocoa nibs) contains about 50 per cent of a solid grease or oil.

Cocoa powder is prepared by heating the chocolate paste and pressing it in a powerful machine till some of this fat or oil is removed. Cocoa is therefore not as rich a food as chocolate, and some people find it more digestible. A further advantage is that it mixes more easily with hot water or milk in making a drink. The same result is obtained by the Dutch process of making cocoa, which consists in treating chocolate with alkali (sodium carbonate or ammonium hydrate). The oil, starch, and albuminoids contained in chocolate and cocoa render them very nutritious, and a small amount of theobromine (which is similar to caffeine) gives them a mildly stimulating effect.

Cocoa butter, or cacao butter, is the solid oil extracted in the manufacture of cocoa.

Cocoa shells, the thin shells broken off the outside of the beans, are used to a small extent, especially in Europe, for making a beverage and for cattle food. In the United States they are generally burned or else sold for fertilizer.

Cacao or cocoa is not the same as coca or coconut.

**Kola.** Kola, or cola, nuts are produced by a tree (*Cola acuminata*) which grows wild in West Africa and is cultivated in Jamaica and Brazil. They contain a comparatively high percentage of caffeine. The negroes in Africa chew the fresh nuts, somewhat as men chew tobacco, coca leaves, or betel, for the

stimulating effect. In America and Europe dried kola nuts are used to make an extract which forms an ingredient of many beverages, especially soft drinks that are said to have tonic properties.

**Various drinks.** Nonalcoholic drinks of many kinds are bottled in immense quantities. Some of these have a basis in malt and hops and are classed as "near beer." (Nonalcoholic malt beverages enter only slightly into international commerce, partly because as a rule they do not keep well.) Others consist of fruit juices like grape juice, sweet cider, etc. Grape juice is reasonably important in the United States and pineapple juice from Hawaii is increasingly popular. Pomegranate sirup (grenadine) is widely sold. Still others are made from various substances which have a pleasant refreshing flavor or some beneficial quality, like ginger ale, sarsaparilla, root beer, etc. These are commonly charged with carbonic acid gas or air under pressure. Mineral waters, plain or effervescent, also have a wide sale. In this group are such waters as Apollinaris and Vichy; some of which are merely pleasant drinks, while others have medicinal properties. (See Alcohol.)

# MEDICINES, STIMULANTS, AND NARCOTICS

Medicines are obtained from the flowers, seeds, leaves, gums, twigs, bark, or roots of many plants and trees. The crude substances which yield medicines are called drugs. The bark or other part of the plant is usually ground and soaked in water or alcohol to dissolve the medicinal principle. Many drugs owe their medicinal qualities to alkaloids or other chemical compounds which occur in the plants. These compounds are very often extracted and used in a state of high purity or else are prepared chemically from other sources than the crude drugs.

Even to enumerate all the substances in commercial use as drugs would take many pages. The products described in the following paragraphs are a few of the most important and characteristic drugs. Nearly all spices, many essential oils, resins, and balsams, seeds like castor beans and purging nuts, and various other vegetable substances are used in medicine. Some substances of animal origin, like cantharides and pepsin, and many of mineral origin, like bicarbonate of soda, Epsom salts, salts of arsenic, iron, mercury, and compounds made from coal tar (such as aspirin), are of great medicinal value. Natural mineral waters often contain lithia, sulphur, magnesia, or other chemical substances. They are bottled and sold extensively on account of their medicinal qualities. Medicinal substances and prepared medicines are an important item in both the imports and exports of the United States.

**Quinine bark.** Quinine bark, cinchona, calisaya, Peruvian bark, Jesuit bark, quina, or quinquina is from several species of trees (*Cinchona ledgeriana*, *C. officinalis*, *C. succirubra*, etc.). These trees are natives of South America, but the commercial

production of bark is from Java, India, and Ceylon. Practically all of it is from cultivated trees, which yield a product richer in quinine and other alkaloids than the wild bark from the Andes, and a supply which can be depended upon. Small amounts of the bark are supplied by Bolivia and the West Indies. The bark is gathered by peeling felled trees or by carefully removing it from living trees in such a way that the growth of the tree is not seriously interrupted and the bark grows again. The renewed bark is richer in quinine than the original bark. Amsterdam is the chief market where Java bark is handled. Very much smaller quantities of bark from India and Ceylon reach London. Quinine bark is sold at prices that are dependent entirely upon the content of quinine as shown by chemical analysis. Holland ships quinine bark and quinine salts (principally sulphate) to the United States, England, and other countries.

**Other barks.** Cascara sagrada is the bark of a tree (*Rhamnus purshiana*) which grows in northern California, Oregon, Washington, and British Columbia. Simaruba, elm, sassafras, and other barks are marketed.

**Seeds and fruits.** Nux vomica seeds (*Strychnos nux-vomica*) come mostly from India (Madras, Bombay, Calcutta, Cochin), Ceylon, and Queensland, Australia. They are the source of strychnine. Strophanthus seeds (*Strophanthus hispidus*) from West Africa, colocynth fruits (*Citrullus colocynthis*) chiefly from Smyrna, physic nuts (*Jatropha curcas*), and many other seeds and fruits are handled in the drug trade.

**Roots.** Rhubarb is the "root," or rhizome, of a plant (*Rheum officinale*) which grows wild in China. The principal supplies of the drug come from Shanghai. There is a small production of dried rhubarb root in central Europe. Aconite root (*Aconitum napellus*) is from various parts of Europe and Asia; jalap (*Ipomœa purga*), from Mexico and India; ipecac (*Psychotria ipecacuanha*), from Brazil, Colombia, and India; gentian (*Gentiana lutea*), from southern Europe; salep (*Orchis* sp.),

from Smyrna; orris (*Iris pallida*), chiefly from Leghorn, Italy. Dozens of other roots are officinal, among them arnica, bryonia, calamus, golden seal, hellebore, mandrake, spikenard, squills, and valerian. Ginseng root (*Panax ginseng*) is valued highly by the Chinese, although our physicians believe that it has no medicinal value. It is gathered in China, Korea, and the United States. Some ginseng is cultivated in this country. Sarsaparilla is the root of vines (*Smilax* sp.) which grow wild in Mexico, Central America, and northern South America. Honduras and Mexico are the chief exporters. A small supply of sarsaparilla is cultivated on the island of Jamaica.

**Woods.** Quassia, or bitterwood (*Quassia amara*), is from the West Indies and northern South America. Lign-aloes (*Aquilaria agallocha*) is from Burma.

**Leaves.** Coca leaves, from a large shrub (*Erythroxylon coca*) which grows in the mountains of Bolivia (Huánuco) and Peru (Trujillo), are the source of cocaine. Most of the crop is used by the natives, who mix the coca leaves with lime and chew them as a stimulant. Some coca is grown in Java. Senna leaves (*Cassia* sp.) are gathered in the region of the Upper Nile (Alexandrian) and in southern India (Tinnevelly); buchu leaves (*Barosma* sp.) come from South Africa; belladonna (*Atropa belladonna*) from Germany and England, henbane (*Hyoscyamus* sp.), digitalis, stramonium, and other leaves are common drugs.

**Hops.** Hops are used chiefly in brewing. They are the dried flowers of the hop vine (*Humulus lupulus*) and are raised largely in the United States in California, Oregon, and Washington. They are cultivated in most countries of Europe, especially in England, Czechoslovakia, and Germany. Hops are added to the malt liquor, or wort, which is then boiled and afterwards fermented by adding brewer's yeast. After fermentation the beer is freed from the yeast, is run into settling-tanks, and is clarified before being placed in kegs or bottles. Hops give a bitter flavor to malt liquors.

**Other flowers.** Indian hemp, or ganja (*Cannabis sativa*), is a resinous drug consisting of the leaves and flowering tops of the hemp plant. It is a fairly important drug in Europe and America. Hashish and bhang, prepared from ganja, are intoxicant narcotics. They are used in India. Chamomile (*Anthemis nobilis*) flowers are chiefly from Germany. Many other flowers yield medicinal products.

**Ergot.** Ergot is a fungus growing on rye produced chiefly in Germany, Spain, and Russia.

**Papain.** Papain is the dried milky juice of the tree (*Carica papaya*) which produces the pawpaw fruit of the tropics. As a rule the juice is collected from shallow cuts made in the skin of the partially ripened fruits. It is produced chiefly in Ceylon and the West Indies (Montserrat). Small quantities are dried in Florida and other parts of the world. Pepsin, prepared from the lining of the cow's stomach, is almost identical with papain.

**Manna.** Manna is a sweet substance that exudes from incisions made in the bark of certain ash trees (*Fraxinus ornus*) of southern Europe. It consists chiefly of a peculiar sugar that is of some medicinal value. Palermo, Sicily, is the chief source of supply.

**Opium.** Opium is the dried juice from the seed pod of the white poppy (*Papaver somniferum*); it is obtained by scratching the growing capsule. The juice exudes in small drops and is collected and further dried. Its production is an important industry in Asiatic Turkey, India, and Persia. Smaller quantities are gathered in Macedonia, Serbia, and Egypt. The culture of opium, as well as the use of the drug for smoking, has been forbidden in China. Until recent years China purchased many millions of dollars' worth of opium annually.

Laudanum is an alcoholic tincture of opium. Morphine, codeine, and other alkaloids of great value in medicine are prepared from opium. Paregoric contains opium. Dealers consider that the drug from Turkey in Asia and the Balkans is

superior in the content of alkaloids to that from India and China and it naturally brings a better price.

**Aloes.** Aloes is a dried juice (*Aloe* sp.) used in medicine. There are three principal types: Curaçao and Barbados, from the West Indies; Socotrine, from Socotra and East Africa, coming chiefly through Bombay; and Cape and Uganda, from South Africa. Two varieties, glassy and hepatic aloes, are marketed.

**Cantharides.** This drug consists of dried insects often called Spanish flies or blistering beetles. Their color ranges from brilliant green to blue, with a metallic luster. The European species (*Cantharis vesicatoria*) is collected in Hungary, Spain, and Italy. Other species (*Mylabris*) are exported from China and India.

**Alcohol, wines, and liquors.** Alcohol, or grain alcohol, results from the fermentation of sugar and is an important ingredient of wine, beer, whisky, and all fermented and distilled drinks. The base for making alcohol is sometimes the starch of grain such as corn, barley, wheat, rye, rice, etc., which is converted by malting into a kind of sugar; sometimes the natural sugar which occurs in sugar cane, grapes, apples, and other fruits is used.

Wine-making, principally from grapes, is a very important industry in southern and central Europe. Until 1919 California and New York were large producers. The wine industry is of growing importance in Argentina, Chile, Cape Colony, and Australia. There is a large international commerce in wines. France, Italy, and Spain are leading exporters. The important types of wine are red, white, dry (or sour), sweet, and sparkling.

Palm wine, toddy or tuba, is made for local use in India, the South Pacific islands, and Africa. Cider is fermented apple juice. The Japanese make a sort of wine called saké by fermenting rice. Pulque is a fermented drink made from the juice of a century plant (*Agave*) in Mexico.

Beer and similar beverages (ale, stout, porter, malt extract) are made from malted grain with the addition of hops, in Europe, Japan, Australia, and South America. Until 1919 the United States was a large producer. The export of malt liquors is a large item in trade from Germany and England.

Distilled liquors are made in many countries and are widely exported. Whisky is made from malt, maize (Bourbon whisky), rye, and other cereals. Great Britain and Canada are the largest makers, although the United States formerly outranked them. Brandy is distilled from wine, principally in France. Gin is made from grain and flavored with juniper berries. Holland and England are the chief producers. Vodka is the Russian equivalent of whisky. Mescal is distilled from agave juice in Mexico. Rum is distilled from fermented molasses or from sugar-cane sirup. It is made in the West Indies and other sugar-producing countries. Arrack is similar to rum or brandy and is made from a base of palm wine, molasses, rice, etc. It is produced in the Far East.

Liqueurs and cordials are sweet liquors made by distilling and mixing various alcoholics with essential oils, flavors, and sirup. *Crème de menthe* (cream of mint), anisette, absinthe, Chartreuse, and curaçao are among the best known of this class.

Repeated distillation yields alcohol that is free from other ingredients which are in whisky, brandy, and rum. Proof spirit, or spirit of wine, contains 49.5 per cent of alcohol and 50.5 per cent of water. When of better quality it is classed as so many degrees O. P. (overproof). Pure alcohol entirely free from water can be prepared only by special chemical treatment. Alcohol is employed as a solvent for nitrocellulose in making artificial silk and for resins in making varnishes and shellac; in the preparation of essences, scents, extracts, and medicines; in the manufacture of many chemicals such as ether and chloroform; in dyeing; for fuel in lamps, stoves, engines, etc. Since alcoholic beverages are usually highly taxed, thus providing a source of considerable government revenue in

many countries, it is necessary to render industrial alcohol unfit for drinking. This is done by adding such things as turpentine, wood alcohol, pyridine, carbolic acid, etc., to give it an offensive taste and odor. Alcohol so treated is said to be "denatured." In Europe much of the industrial alcohol is made from potatoes.

Wood alcohol, methyl alcohol, or wood naphtha is different chemically from grain alcohol. It is obtained by the distillation of wood. It is an important solvent, useful for many of the same industrial purposes as other alcohol. It is extremely poisonous and is much used for denaturing grain alcohol. The resultant mixture is often called methylated spirits.

**Tobacco** (*Nicotiana tabacum*, *N. rustica*, etc.). Tobacco was originally a native of America. Since 1558 it has spread over the entire world. It is now used commonly not only by civilized peoples but also by savage tribes and peoples in districts where modern civilization and commerce have not penetrated.

The plant is very frequently grown on small fields, although it is sometimes grown on large plantations. Much of the finest-quality leaf is raised under cheesecloth, acres of land being covered by thin awnings that are supported on poles. This gives the plants a little protection from the direct rays of the sun and considerable protection from the wind, and it also prevents the rapid evaporation of moisture from the ground. In some places (for example, in Pennsylvania) tobacco plants are cut at the root, and the entire plant is hung up to dry; in other places the plant is cut in sections; in still other localities (in Cuba, for example) the leaves are gathered one at a time as they become properly matured.

The leaves are cured by varying methods. If the fresh green leaves are dried quickly, they have practically none of the peculiar aroma of tobacco. This is developed only by slow drying, accompanied by a certain amount of fermentation, or "sweating." In most countries the curing is done in barns built so that the ventilation can be regulated according to the heat, the moisture of the air, and the progress of curing. Some to-

Fig. 18. Tobacco Harvest in Pinar del Río, Cuba

Fields of large extent are covered with cheesecloth, to protect the leaves from the direct sun and the wind, thus preventing undue evaporation and at the same time making easier the control of insects. In Cuba the leaves are gathered one by one, whereas in other parts of the world the entire plant is often cut off at the ground

bacco is sun-cured and some is dried partly under a shed and partly in the open air. After being cured, the tobacco is graded according to color, aroma, and appearance. The grades are so numerous that long experience is required before leaf tobacco can be judged and classified correctly and properly. Leaves of one size and grade are tied together into "hands." If intended for cigars, the hands are then packed away in warehouses to age, or ripen, thus further developing the flavor. The many flavors of tobacco on the market result from the production of the leaves by different species and cultivated varieties of the plant, under varied conditions of soil, climate, and culture, and from the different methods of curing. Tobaccos of different qualities are blended skillfully so that the article offered for sale may please the buyer as to flavor, strength, aroma, and color.

Cigar tobacco is divided according to its appearance into "wrappers," "binders," and "fillers." Sumatra leaf is valued especially for wrappers.

Cut tobacco for smoking in pipes or for making cigarettes is frequently roasted and is often flavored with molasses, vanilla, cloves, chocolate, etc. Chewing-tobacco and plug tobacco are almost invariably flavored, licorice and vanilla being frequently used for this purpose. Snuff is powdered tobacco leaves, midribs, and stems, and it is always scented.

The stems and midribs of the leaves discarded from the manufacture of cigars and cut tobacco are used for fumigating greenhouses and for making extracts for killing insects. Such extracts are mixed with other things in sheep dip, a compound which is useful in ridding sheep of vermin. Stems and midribs are rich in potash and are therefore used as fertilizer.

The effect of tobacco on the human system is due to nicotine, a narcotic alkaloid.

Tobacco is grown in almost every country in the world, but the United States is the largest producer. The leading states in tobacco-growing are Kentucky, North Carolina, Virginia, Tennessee, Pennsylvania, South Carolina, Connecticut, and

Wisconsin. In total quantity of tobacco produced the leading countries are the United States, Brazil, Greece, India, Japan, and the Dutch East Indies. Other large growers of tobacco are France, Italy, Germany, Bulgaria, Hungary, Jugoslavia, Russia, Algeria, and the Philippines. The chief exporters are the United States, the Dominican Republic, Cuba, Brazil, Algeria, Greece, Turkey, India, the Dutch East Indies, and the Philippines. Sumatra tobacco is handled mostly through Amsterdam. Louisville, Kentucky, is the greatest tobacco market in the world.

Cuban (Havana), Sumatra, Philippine (Manila), and Turkish tobaccos bear the highest reputation. Havana and Sumatra tobaccos are grown to some extent in other localities; for example, in Connecticut, where true Havana seed, planted under cheesecloth, produces leaf of high grade.

The tobacco business is a source of revenue to almost every government in the world and is a government monopoly in France, Spain, Portugal, Italy, Rumania, Turkey, and Japan.

**Areca nuts.** Areca nuts, sometimes called betel nuts, are chewed by the people of India and by the Malays and Chinese throughout southeastern Asia and the East Indies. The nuts, the seeds of the areca palm tree (*Areca catechu*), are boiled, sliced, mixed with a little lime, and then chewed with a leaf of betel pepper. Areca nuts are also used in medicine.

# OILS, FATS, AND WAXES

The seeds and fruits of many plants are rich in oil, this being the concentrated form in which nutriment is stored for the early growth of the young plant. Nearly all animals possess fats, which are frequently stored in the abdominal cavity or in a layer under the skin and are capable of being rendered into oil.

The vegetable and animal oils referred to are called fatty oils and are similar in general composition and in many of their properties. Most of them are liquid at ordinary temperatures; some are solid white fats. Chemists call them all glycerides, or combinations of glycerol and fatty acids. When fatty oils are mixed with caustic soda and water, soap is formed. Careful tests show slight differences in these oils, and technical books give a saponification value by number to every oil. Similarly, every oil has a number called its iodine value, which refers to its ability to absorb iodine. These tests are of value in helping to identify oils or to determine their purity. Other standard tests are the determination of the viscosity, which has to do with the lubricating quality; the fire test and flash point, which have to do with the burning quality; the cold test; the specific gravity; the evaporation test; the free-fatty-acid test; etc. Waxes are much like fatty oils in their composition, except that they are nonglycerides. Fatty oils and waxes are very different from essential oils and mineral oils in composition and in most of their properties and uses. Fatty oils resemble mineral oils in being rather thick liquids with a greasy feel and in being useful for lubricating and burning.

Vegetable oils are usually obtained from seeds by pressing (or "expression"). Preparatory to this the shells or hulls of most seeds need to be removed by a hulling-machine. Then the

meats are ground to a coarse meal. If "cold-drawn" or "cold-pressed" oil is to be made, the meal is formed at once into cakes about two inches thick, which are wrapped in strong porous cloth made of cotton, horsehair, camel hair, or human hair. If "hot-pressed" oil is being made, the meal is first heated or cooked in kettles heated by steam pipes and is then formed into cakes. The cakes are slid into grooves in a machine, where they are squeezed under very powerful hydraulic pressure. The oil runs out, is carried away by pipes, and is collected in tanks. If cold-drawn oil has been made, the hard-pressed cakes are removed from the machine, ground to a meal, heated, and again pressed. The second running of hot-pressed oil is poorer in quality than the first. Often there is a third pressing, and each time the heat and the pressure are increased. Some seeds, such as peanuts, cacao beans, castor beans, and coconuts, are so rich in fat that the oil is actually half the weight of the seed. Others, such as soy beans, contain as little oil as 18 per cent. Some seeds are first cold-pressed, and then the residue is treated with solvents to extract lower-grade oil.

Oil cake, or press cake, is the solid residue from which the oil has been pressed. It is rich in nitrogen and is valuable for cattle food and as a fertilizer. It is usually ground up, and the resultant oil-cake meal is mixed with other things in prepared feed for stock. The most efficient modern method of separating oil from seeds is termed expression. This is handled by machines of a different type, and a residue of meal is formed instead of a solid oil cake.

Edible oils are practically all obtained by pressing, but a larger quantity of oil can be extracted by solvents. The usual procedure in "extracting" vegetable oils is to put the seed meal into closed tanks with bisulphide of carbon, carbon tetrachloride, petroleum ether, naphtha, or benzine. These liquids dissolve the oil, leaving a meal unsuitable for feeding to animals but valuable as a fertilizer. The solvents are easily separated from the oils by distillation.

Animal oils are usually separated from the fatty tissues by heat (boiling or rendering).

The greatest centers in the world for pressing vegetable oils and therefore the most important wholesale markets for the purchase of oil seeds and for the sale of oils are Marseille, Hull, Hamburg, and Trieste. This statement applies to vegetable oils in general but not to cottonseed oil, olive oil, and a number of other oils. The United States consumes more fats and oils than any other nation; although a large producer, it is also one of the principal importers, especially of seeds and oils not produced in this country.

Vegetable and animal oils are used for the table, for cooking, for medicines, for soap-making, lubricating, illuminating, mixing paints and varnishes, making oil cloth, artificial leather, and rubber substitutes, dyeing, preparing skins and leathers, oiling fibers to aid in spinning or to prevent brittleness in rope and twine, etc.

Nearly all vegetable oils have more or less odor, and this sometimes makes an oil which is otherwise of good quality unacceptable for food or cooking. Such oils are often deodorized by having superheated steam blown through them. This process is often applied to cotton, peanut, and olive oils to improve the grade. Chemicals are also used in treating oils to purify them.

Oils are frequently allowed to stand and to cool in tanks for a time (even for several years). Stearine, a white, waxy-looking substance, often separates, and various elements settle to the bottom. The clear oil which remains is usually termed winter oil, and the part which settles is known as foots. Oils are filtered through fuller's earth or bone black to decolorize or bleach them.

Many vegetable oils are "hardened," or "hydrogenated." This process consists in passing hydrogen gas through oil in which finely powdered nickel has been stirred. The nickel acts as a catalyzer, and the hydrogen unites with the oil, changing it from a yellow liquid to a solid white substance resembling

lard. Such hardened oils, as well as vegetable and animal fats, are used in preparing cooking-fats and substitutes for butter.

In soap-making a fatty oil is heated, and there is added to it a weak solution of alkali, such as caustic soda (lye) or caustic potash, which unites chemically with the oil, forming soap and glycerin. Soap being insoluble in brine, salt is then added, and the soap rises to the top of the kettle, and the brine, together with the glycerin, is drawn off from below. The soap is then purified and is usually mixed with ingredients to color and scent it. Mineral matters, such as sand and pumice, are added in making scouring soaps. Rosin can also be saponified and is much used with oils in soap-making, as are also certain waxes. Candles are made from solid fats and waxes by a process similar to making soap.

**Glycerine.** Glycerine is obtained as a by-product in the manufacture of soaps and candles. It is used in pharmacy, in various industrial processes, and very largely in the manufacture of nitroglycerin and dynamite.

### DRYING OILS

Oils of this class when exposed to the air absorb oxygen and form an elastic skin resembling varnish. These oils are particularly suitable for paint and varnish. They are valuable also for making linoleum, imitation leather, waterproofing, etc., and, like all fatty oils, they are used in soap-making. Such oils are not appropriate for lubricating. They are sometimes used for food or cooking, but such use is not general. Drying oils are heated with litharge or other "driers" in order to hasten the hardening of paint and varnish. After this process they are called boiled oils.

**Linseed oil.** Linseed oil is pressed from flax seeds (*Linum usitatissimum*). This is the standard oil in the manufacture of paint and varnish. The seeds are grown in greatest quantity in Argentina, yielding La Plata, or River Plate, oil; in India, yielding East India oil, even if pressed in Europe or America;

in Russia, yielding Baltic or Black Sea oil; and in the north central United States, Canada, and North Africa. The United States is one of the chief producers and is also a large importer of flax seeds. Some cold-pressed linseed oil is used for food purposes in Russia, Hungary, and India.

"Boiled" linseed oil is used in very large quantities. After much actual boiling the oil becomes very thick and is the basis for printer's ink. Linoleum is made of linseed oil mixed with cork and gums. Linseed-oil cake is a standard cattle food.

**Wood oil.** Wood oil, Chinese wood oil or tung oil, is from the seeds of a tree (*Aleurites fordii, A. cordata*) which grows abundantly in central and southern China and in Indo-China. As a rule this oil is pressed in China, not in Europe. The export trade of wood oil has grown very much since 1900. Its commercial importance is indicated by the fact that it is sometimes shipped in tank steamers. Tung oil has remarkably good drying qualities. It is seldom or never used raw, but is prepared by heating in open kettles to a comparatively high temperature. After this treatment it will harden rapidly. Varnishes mixed with it resist water, heat, and acid fumes. It is used in paint, linoleum, and similar products, and is valuable for making waterproof insulation for electric apparatus.

Several related species of trees in the Philippines and elsewhere in the Far East produce nuts containing oils that are similar but not identical. Candlenut (*Aleurites moluccana*) is the most important of these.

**Sunflower oil.** Sunflower oil is from the seeds of the common sunflower (*Helianthus annuus*). It is used in paint, but is most important in southern Russia as a butter and a cooking-oil. The seeds come from the Caucasus, Hungary, India, China, Argentina, South Africa, etc. Sunflower cake is much used for cattle feed in Denmark and Sweden.

**Poppy oil.** Poppy oil, or maw oil, is made from the seeds of the opium poppy (*Papaver somniferum*) and related plants. The plants are cultivated in Europe, Asia Minor, and India

for the seeds, which vary in color from white to gray or red. The oil is used for food and in artists' paints.

**Walnut oil.** Walnut oil, or nut oil, is from the kernels of "English" walnuts (*Juglans regia*). This oil dries rapidly and is almost colorless. Artists frequently use it for mixing paint.

**Hemp oil.** Hemp oil is from the seeds of the plant (*Cannabis sativa*) which yields hemp fiber. The seeds are exported from Russia, from the province of Manchuria and other parts of the Chinese Republic, and from India. Many European countries are also producers. Canary birds are fond of these seeds.

**Menhaden oil.** Menhaden oil is from the menhaden, or mossbunker, a fish (*Brevoortia tyrannus*) of the North Atlantic coast of America. This is a drying oil, when not adulterated with salmon or sardine oil. It is especially valuable in making paints for metals, because it sets with a flexible film, not a brittle one. It is often thickened by being boiled in open kettles or by having air blown through it. Menhaden oil is much used for tanning buckskin and chamois leather and frequently for oiling rope and for making soap.

**Other drying oils.** Perilla seeds (*Perilla ocymoides*, from Japan and China), the seeds of the Pará rubber tree (*Hevea brasiliensis*, from plantations in the Far East), and the seeds of the Ceará rubber tree (*Manihot* sp., from Brazil and Africa) produce drying oils which are increasing in use. Niger seed (*Guizotia abyssinica*, from India, Siam, and East Africa), safflower seed (*Carthamus tinctorius*, from India), argemone seeds (from the East Indies), madia seeds (from Chile), and pinetree seeds (from Europe) yield drying oils of minor commercial importance.

## SEMIDRYING OILS

Semidrying oils are intermediate between drying and nondrying oils. After proper preparation they can be used in paint. They are valuable for food, for making soap, and for nearly all the other uses for which oil is employed.

**Cotton oil.** Cotton oil, or cottonseed oil, is one of the most important oils in commerce. Cotton seeds are first ginned to remove the fiber. "Upland" cotton seeds require further ginning to remove the linters and the delint. The clean seeds are hulled by special machinery; the hulls go into feeds for stock and, more rarely, into paper pulp. The meats, or kernels, are then ground and commonly hot-pressed to extract the oil.

FIG. 19. Cotton-Oil Mill in New Orleans, Louisiana

The three wheels in the distance are part of a mill which grinds up the cotton seeds. Then they are heated in the "cookers" at the left. The oil is pressed out in the hydraulic apparatus at the right, which is purposely set at a little slant so that the oil will flow away in one direction

Cotton oil is a very important export of the United States. It is made in China, Japan, India, Egypt, and other countries, and is usually imported into the United States in fairly large quantities.

Crude cotton oil is refined by treatment with alkali, yielding "prime summer yellow oil." When the stearine is removed, usually by cooling, we have "winter yellow oil." Filtering through

fuller's earth takes out much of the yellow color, giving "summer white" or "winter white" oil. Purified oils free from odor and flavor go into table oil, salad oil, and cooking-oils, and are used for packing sardines. Hardened, or hydrogenated, oil is used in "hogless lard" and imitation butter. Lower-grade oil after special treatment goes into paint. The alkali used in refining combines with part of the crude oil, giving soap stock which analyzes high in fatty acids.

Cotton-oil cake is an article which takes a high rank among the exports of the United States. It is a very nourishing cattle food and is used extensively on the dairy farms of Europe.

**Corn oil.** Corn oil, or maize oil, is pressed (chiefly in the United States) from the germs of corn from which starch has been made. It is one of the most valuable products of a cornstarch factory. Corn oil is increasing in importance; its uses include food, soap-making, oilcloth, linoleum, substitutes for leather, paints, and varnishes. It is one of the chief oils used in making a substitute for rubber; for this purpose it is heated with sulphur. Chemical treatment changes the nature of corn oil so that it will mix with water. This soluble oil is of value in the textile industry (see Turkey-red oil).

**Sesame oil.** Sesame oil is from the seeds of a plant (*Sesamum indicum*) which is cultivated in India, the Far East, and Mediterranean regions, and in smaller amounts in other countries. It is used for food, for making soap, etc. The seeds are known under such name as "til," "teel," "gingelly," "ajonjoli," etc. Sesame seeds are sometimes used as a spice. The best-quality seed is white, but some varieties are black in color. Cameline, or German sesame seeds (*Camelina sativa*), and African beni seeds yield similar oils.

**Rape oil.** Rape oil is a general term applied to several oils which resemble each other closely. They are from the small round seeds of various species of plants (*Brassica*) related to mustard. Rape oil is a very important oil in commerce. It is also known as colza oil, rübsen oil, etc. Ravison oil is from

Black Sea rape (*B. campestris*). The seeds are produced in almost all parts of Europe, India, China, and Japan. Rape oil is important for burning and lubricating. Refined rape oil is the usual sanctuary oil used in Roman Catholic churches, because it will burn for days with a clear flame. Blown rape oil mixes with mineral oils, making lubricants of especial value for ocean steamers. It is "vulcanized" by treatment with sulphur chloride, and the resultant substance has many of the qualities of rubber, for which it forms a cheap substitute. Oil of mustard seeds (*Sinapis* and *Brassica*) and jamba oil are similar.

**Bean oil.** Bean oil (soja, soya, or soy-bean oil) has been important in Europe and America only since the year 1907. It is obtained from a kind of bean (*Glycine hispida*) which is grown in Manchuria, northern China, and Japan. Soy beans vary in color from white or yellow to green or black and are cultivated in North America and Europe chiefly for forage. They are exported in large quantities from Manchuria to England, France, and the United States. Thousands of tons are pressed annually in the oil mills of Seattle and Vancouver and in Europe. There are modern oil mills in Vladivostok and other cities in that part of Asia, but their output is less than that of Europe.

Bean oil is used in making soap, linoleum, printing-ink, as a substitute for rubber, and for waterproofing. The best qualities are used for food. On account of its "bleaching out" properties bean oil is much used in flat white paints.

Bean cake is valued as cattle food in Europe. For many years it has been exported from northern China to Japan for fertilizer and cattle food.

**Kapok oil.** Kapok oil, from the seeds of the East Indian cotton tree (*Eriodendron anfractuosum*), is similar in its properties to cottonseed oil. It is pressed in the Netherlands from seed imported from Java.

**Other semidrying oils.** Semidrying oils are pressed from pumpkin, cucumber, and melon seeds; from the kernels of

Brazil nuts and mucuna seeds of Brazil; from croton seeds from southern Asia; from purging nuts, or physic nuts (*Jatropha curcas*), from tropical America; and from various other seeds. Oil is extracted commercially from some unexpected sources; for example, tomato seeds. These are a by-product in factories where table sauces are made. Many tons of tomato seeds accumulate annually at such establishments in Parma, Italy, and yield tons of tomato-seed oil.

## NONDRYING OILS

Nondrying oils remain fluid even after long exposure to the air. Many of them are good lubricants, excellent for table use and cooking and, of course, for making soap. "Sweet oil" means almost any nondrying oil of good edible quality. For lubricating purposes some nondrying oils are "blown" by the passing of air through the heated oil to render it thicker and more viscous.

**Olive oil.** Olive oil is obtained from the flesh, or pulp, which surrounds the seed, or nut, of the olive tree (*Olea europœa*). The usual practice is to crush or grind the entire fruit in a mill and then press the pulp, or marc, in a machine. At first it is pressed lightly and yields oil of high quality, generally known as virgin oil. The next pressure is heavier and also yields edible oil, often called table or salad oil. After the second pressure the marc is broken up, is mixed with hot water, and is again pressed more strongly. This is ordinary oil, and generally has a greenish tinge. Finally, the marc is treated with bisulphide of carbon to dissolve out the last of the oil, which is sold in the market under the name "sulphur" oil. This is a nonedible olive oil useful for soap-making, for lubricating, and for burning. All these grades of olive oil need to be purified to separate the oil, water, and sediment. When the lower grades are treated with alkali to purify them, there is a separation of "olive foots." If the seeds of the olive are separated from the pulp, they can be pressed to yield olive-kernel oil; but very

commonly they are ground up with the pulp, and the kernel oil becomes blended with the oil from the pulp.

Olive oil is produced in practically every country bordering on the Mediterranean, both to the north and the south, especially in Spain, Italy, and France. Southern California produces a little, and there is some prepared in South Africa and northern Australia. It is used very extensively for food and cooking in Europe, western Asia, northern Africa, and America. It is employed also for packing sardines, for lubricating, and for burning. Genuine castile soap is made from olive oil.

Since olive oil is one of the highest-priced and most popular of all the vegetable table oils, it has very often been adulterated with such oils as cottonseed, peanut, sesame, etc. Several European countries having an important export trade in olive oil naturally desire to maintain their reputation for a product of high quality. To prevent adulteration, therefore, they forbid by law importation of cottonseed oil unless it has been denatured. This means that some substance has been added which has such an unpleasant taste and odor that the oil cannot possibly be used in food products. The treatment does not prevent the use of such cottonseed oil for making soap and for other industrial purposes.

**Peanut oil.** Peanut oil, or arachis oil, is from a plant (*Arachis hypogæa*) which grows in almost all the warm parts of the world. The seeds (earthnuts or groundnuts) are exported in largest amounts from Senegal and other countries of West Africa and from India. They are largely grown in Japan, China, East Africa, South America, and the United States. Peanut oil is much used for food and in the manufacture of soap.

**Castor oil.** Castor oil is obtained from the seeds ("beans") of a plant (*Ricinus communis*) which grows in all tropical countries. India is the largest producer, but Brazil, Haiti, and various other countries help to supply the world's market. There is some production of castor beans in the United States.

For medicinal purposes the cold-drawn oil is used exclusively. Castor oil is a remarkable lubricant and is especially valued for use in airplane engines. It is valued also as a dressing for leather and in making soap.

**Turkey-red oil.** Probably the largest amount of castor oil is used in the preparation of turkey-red oil (soluble oil or sulphonated oil) for dyeing and printing textiles. For this purpose it is treated with sulphuric acid. Olive, cotton, corn, cod, menhaden, and similar oils are sometimes used instead of castor oil. Sulphonated oil is unlike the original oil in being soluble in water or mixing readily with it. Fabrics treated with sulphonated oil can be dyed or printed with certain colors by which they are unaffected before treatment with the oil, which also has a tendency to make colors brighter. It is used in the preparation of "sizes" for textiles and is replacing tallow or other fats as a softener.

**Almond oil.** Almond oil, or oil of sweet almonds, is actually made by pressing the kernels of bitter almonds (*Prunus amygdalus amara*). The oil cake is then treated to extract the essential oil of bitter almonds. The kernels come from Mediterranean countries and from as far east as Persia.

**Other nondrying oils.** Nondrying oils are made from the kernels of the apricot, peach, plum, cherry, hazelnut, cashew nut; from ben, or moringa, seed (*Moringa oleifera*) from the East Indies and Nigeria; from tea seeds (*Camellia* sp.) from China, India, and Ceylon; and from many others. Grape-seed oil is a by-product from the preparation of seeded raisins in some California factories.

Animal oils are mostly of the nondrying type.

**Whale oil.** Whale oil, or train oil, is chemically a liquid wax obtained from the blubber, or fat, of whales by heating with steam in special boilers. The oil comes in three grades: "spring" oil, "summer" oil, and "winter" oil. The best is winter sperm, from which the spermaceti has been separated. Lower-grade oil is made from the flesh and bones. Whale oil

is extensively used in dressing leather, in the preparation of manila rope, for lubricating, for burning, and in soap-making. Whale-oil soap is used for killing insects on trees. The best grades of sperm oil are employed for lubricating light machinery and in the recoil of large cannon. A special grade of whale oil from the head cavities is used for oiling watches.

The chief whale fisheries are in the South Atlantic Ocean, near the South Shetlands, South Georgia, and the Falkland Islands. Whales are also taken in Bering Sea, off the coasts of Chile, West Africa, Southeast Africa, Mozambique, Australia, and northern Japan, and in the North Atlantic. New Bedford, Massachusetts, is one of the chief markets for whale oil. This oil is handled in Labrador, Newfoundland, Canada, Norway, and Japan. The best oil is from the true sperm whale (*Physeter macrocephalus*). Much oil comes from the right whale (*Balæna mysticetus*), but other species are hunted and give their names to such oils as bottlenose oil.

**Various oils.** Fairly important oils are from the fat of the seal (*Otaria*), the porpoise (the dolphin or blackfish), and the shark. Turtle oil, dugong oil, and rattlesnake oil are little used.

Fish oils are made either from the entire fish or from the heads and intestines. Herring, sardines, salmon, and other fish furnish oils of this type (see Menhaden oil). Waste from the manufacture of fish oils, along with other fish refuse, is dried and marketed as "fish guano."

**Cod-liver oil.** Cod-liver oil is obtained by heating the livers of the codfish (*Gadus callarias*). The best quality is used in pharmacy, and the less pure, darker-colored oil in dressing chamois and other leather. The livers of some other fish yield oil which is often sold under the name of "cod oil." The chief production is in Norway, Iceland, Scotland, Newfoundland, Canada, and Japan.

Sulphonated cod oil is made by treating cod oil with sulphuric acid (see Turkey-red oil). It mixes readily with water and is employed largely in dressing leather.

| | | |
|---|---|---|
| WHALE | Fat (or blubber) | Sperm oil, train oil, spermaceti, soap, illuminating oil, candles, leather-dressing, lubricants |
| | Meat: food (fresh or canned), fertilizer, whale guano, oil | |
| | Bone: oil, fertilizer, framework for Eskimo houses | |
| | Baleen: whalebone | |
| | Ambergris: perfumery | |
| | Teeth: ivory | |
| | Skin: porpoise leather | |

**Wool grease.** Wool grease (wool fat, yolk, wool wax, or suint) is the natural oil of sheep's wool. Relatively small quantities of this substance are saved, for most wool-washing establishments make no attempt to recover it. Crude wool grease (brown wool grease or degras) is used for making soap, for preparing upper leathers, for lubricating, etc. Refined wool grease (lanum, adeps lanæ, or lanolin) is used in cosmetics and toilet preparations.

The name "degras" is also applied to sod oil, the excess oil removed after currying leather. It is used in stuffing leather and in dressing belts.

### VEGETABLE AND ANIMAL FATS

These substances are of the same nature as the thinner oils, differing a little in chemical composition and reactions. They are valued for food, for cooking, and in soap-making.

**Coconut oil.** Coconut (or cocoanut) oil is pressed from the dried white meat, or kernel, of the coconut (*Cocos nucifera*). It is a clear oil at temperatures above 100° F., and a solid white fat like lard at lower temperatures. Dried coconut meat, or copra, is prepared in enormous quantities in tropical countries. It comes on the market in largest amounts from the South Pacific and Indian oceans, and especially from the Philippines, the Dutch East Indies, Ceylon, the Straits Settlements, and the Malay States. It is exported from India, East Africa, Madagascar, the Seychelles, and Mauritius, and it is gathered by traders in almost all the islands of the South Pacific and in relatively

small quantities from Trinidad and other places in the West Indies. Copra is commonly dried in the sun, less frequently over a fire (smoke-dried), and in small amounts in modern drying-machines.

Coconut trees grow in coastal regions throughout the tropics, and the oil is made and used locally almost everywhere that the tree is found. It is the indispensable cooking-fat for millions of native people and is used widely for burning in lamps, for rubbing on the skin, and for lubricating.

- COCONUT-PALM TREE
  - Fruit
    - Kernel
      - Food
      - Copra
        - Coconut oil
          - Soap
          - Cooking-fat
          - Butter substitute
          - Coconut stearin
        - Oil cake
    - Milk a beverage
    - Shell
      - For cups and bowls
      - For gas-mask charcoal
    - Husk: coir fiber for brushes, carpets, ropes, etc.
  - Trunk
    - For construction
    - For firewood
    - Porcupine wood for cabinetwork
  - Leaves
    - Leaf bud for food
    - Thatching, mat-weaving, basket-making, etc.
  - Flower spathe
    - Juice
      - Palm sugar
      - Beverage
        - Unfermented
        - Fermented (toddy)
          - Distilled (arrack)
          - Vinegar

Coconut oil is pressed in extremely large amounts in Europe and America and is produced for export, in modern mills in the Philippines, Cochin China, India, and Ceylon. Its importance may be inferred from the fact that there are coconut-oil mills in the United States that pump the oil through pipe lines to a railroad siding in order to load the tank cars in which it is shipped. It is pressed locally in primitive mills almost everywhere that the tree grows. The oil is used in the manufacture of soap and candles, and the better grades are used for cooking. Soap made from coconut oil is remarkable for its free-lathering quality. The best grades, free from taste, odor, and rancidity,

not showing free fatty acids, and having a high melting-point, are used in artificial butter (nut margarine).

Coconut-oil cake, or poonac, is one of the most important of all oil cakes, being high in nutritive value, and is much used for feeding cattle.

The solvent process is employed largely in Germany for the extraction of palm oils. The residue (*schrot*) is rich in protein but low in oil, in that respect being inferior to press cake.

**Palm oil.** Palm oil is sometimes used in a general way to mean the many oils which are prepared from the fruits of various palm trees. In commerce it is applied to a solid or semi-solid fat which is separated from the pulp of the fruits of the West African oil palm (*Elœis guineënsis*). This tree grows wild in lowlands throughout western and central Africa. The reddish fruits, each the size of an egg, grow in clusters weighing perhaps seventy-five pounds. The fruits are mashed and boiled to free the pulp from the fat or tallow, a reddish to yellow substance which is one of the most important products of the African forest. The export from Nigeria (Lagos) and Belgian and French Congo, worth millions of dollars annually, goes mostly to France and England. Its chief use is in making soap and candles and for coating sheet iron to prevent oxidation in the manufacture of tin plate. In central Africa it is the indispensable fat for cooking.

Related palms grow in South America, the Philippines, and other countries, but there is no other important commercial production of this type of oil from the pulp of palm fruit. However, there is actually a very large production of this oil for local use in parts of eastern Brazil, where it is called dendé oil. Tucum oil of French Guiana is similar.

**Palm-kernel oil.** After the pulp is removed, the seeds of the West African oil palm consist of a white kernel inclosed in a very hard black shell. The nuts are cracked, generally by hand, and the kernels are exported in large amounts. The oil made from these palm kernels is in many ways similar to

coconut oil. In a general sense palm-kernel oil might be any oil from the kernels of the seeds of any palm, but in commerce its meaning is definitely restricted to this oil.

**Cohune oil.** Cohune oil is from the kernels of the hard nuts of the cohune-palm tree (*Attalea cohune*) of Central America and southern Mexico. These seeds are produced in very large quantities, but are not of great commercial importance, partly because, like many other palm nuts, the shells are very difficult to break without damage to the meat.

There are dozens of other palm fruits with kernels which contain oil, but the total actual commercial production is small. Coquillo nuts from Central America and babassú kernels (Fig. 20) from Brazil are increasing in importance.

**Cocoa butter.** Cocoa butter, or cacao butter, is the solid oil extracted from chocolate beans when cocoa is manufactured. It has a high melting-point and does not easily turn rancid. It is added to some kinds of chocolate candy to make them richer and is used in the making of cosmetics, pomades, and salves.

**Chinese vegetable tallow.** Chinese vegetable tallow is a hard fat which coats the seeds of a tree (*Stillingia sebifera*). It is produced in large quantities in central China, Indo-China, and northern India. A large amount is exported from Hankow. Its chief use is in making candles.

**Shea butter.** Shea butter (karité, bambuk, or galam butter) is a fat prepared by West African natives from the kernels of the seeds of a large tree (*Butyrospermum parkii*). It is a very important food fat in Dahomey and other parts of tropical Africa. The fat and also the seeds that yield it are exported to Europe and America, but not in great amount.

**Other vegetable fats.** Mowrah-seed oil, mahua butter or dolia oil (*Bassia latifolia*), illipe butter (*Bassia longifolia*), and phulwara, or fulwa, butter (*Bassia butyracea*) are from India.

Carapa butter, talicoona (toucoulouna, touloucouna) oil, crabwood oil, and andiroba fat are from various species of *carapa* seeds from Brazil, West Africa, and India.

Fig. 20. Babassú Kernels, Pará, Brazil

These are the seeds of a wild palm tree of the Amazon. They are of increasing importance in export trade

Dika butter, or oba oil (*Irvingia* sp.), is used as food by West African natives, as is a similar substance, cay cay wax (or candle-tree fat), in Indo-China. Kokum, or Goa, butter (*Garcinia* sp.), Borneo tallow (*Shorea* sp.), and niam fat are among dozens of such substances which reach European markets in comparatively small quantities.

Nutmeg butter (mace butter) is pressed hot from ground nutmegs. It is used in medicinal preparations.

**Chaulmoogra oil.** Chaulmoogra oil, from the seeds of a tree (*Taraktogenos kurzii*), is from India. Its chief use is in the treatment of leprosy.

**Tallow.** Tallow is made by heating the fat, or suet, of cattle or sheep and straining the resultant liquid; the process is known as rendering. Tallow is used in making soap and candles, for lubricating, and in dressing skins and leathers. Oleo oil and oleostearin are used in butter substitutes. Tallow oil and bone grease are low-grade oils.

**Neat's-foot oil.** Neat's-foot oil is made by boiling the feet of cattle. It is a valuable lubricant. Sheep's-foot oil and horse's-foot oil are similar.

**Lard.** Lard is the rendered fat of the hog, graded as "leaf," "prime," "neutral," etc. Its chief use is as a foodstuff. Lard oil is obtained by placing lard in woolen bags and submitting it to heavy pressure. It is used for lubricating, lighting, and as an adulterant for other oils.

**Stearin.** Stearin, for candle-making, remains after the oil is pressed from lard.

**Butter.** See Foods.

Low-grade fats and oils are recovered from garbage and sewage in modern disposal plants.

## WAXES

Waxes are classified in two different ways: Commercially they are grouped as below because of their appearance and uses. Chemists, however, put Japan wax and bayberry wax in the

class with vegetable fats and thus separate them from the true waxes. (See also Spermaceti; sperm oil, under Whale oil; Tallow; Stearin; wool wax, under Wool grease; and mineral waxes: paraffin, ozokerite, and montan wax, under Petroleum; halowax, under Coal.)

All these substances have many qualities in common with beeswax and can be used for similar purposes. They are valuable for making candles, floor wax, furniture polish, wax matches, waxed and glazed paper, wax crayons, tree wax, grafting-wax, wax fabrics, artificial leaves, models, leather-dressing, phonograph records, lubricants, insulation, waterproofing, etc. Very frequently they are mixed in actual use.

**Carnauba wax.** Carnauba, or carnahuba, wax occurs as a surface coating on the leaves of the carnauba-palm tree (*Copernicia cerifera*) in Ceará and adjacent parts of Brazil. The leaves are dried, and the white powdery wax is scraped or shaken off. It is then melted into cakes, and thousands of tons are exported annually. This is the hardest wax on the market. It is used especially for the manufacture of polishing-pastes, shoe polish, and glazed papers. It was formerly used for phonograph cylinders.

**Candelilla wax.** Candelilla wax of northern Mexico comes from the surface of the stems of a plant (*Pedilanthus pavonis*) which grows in a semidesert region. Most of it is marketed through Laredo, Texas.

**Japan wax.** Japan wax, or Japan tallow, is a hard vegetable fat obtained from the fruits of various species of sumac (*Rhus succedanea*, *Rhus vernicifera*, etc.) growing in southern Japan. A little is gathered in China and Indo-China.

**Bayberry wax.** Bayberry wax (myrtle wax, myrtle-berry wax, or laurel wax) is a hard fat found coating the fruits of several species of myrtle bushes (*Myrica* sp.) which grow wild on the north Atlantic coast of the United States, in Central America, northern South America, and Cape Colony. It has a pleasant aroma and is used for candles.

**Raffia wax.** Raffia, or raphia, wax of Madagascar comes from the leaves of the same palm tree (*Raphia pedunculata*) that supplies raffia fiber. Pisang wax (*Cera musa*) is exported from Java.

**Insect wax.** Insect wax (Chinese wax or pela wax) is deposited on twigs by an insect (*Coccus pela*) which is found in western China. It is employed in furniture waxes, in leather-dressing, in sizing paper, in dressing silk and cotton fabrics, etc.

**Beeswax.** Beeswax is obtained by melting the comb from hives where bees have stored honey. It comes from farms where honey is produced and from the combs of wild bees. The best quality, which is light in color, is from combs that the bees have used but once; old combs make brown wax. Beeswax is usually bleached, either by sunlight and moisture or by the use of acids. It is commonly melted by the heat of the sun and molded into cakes. It is in many ways the standard wax of the world and is largely adulterated. It is produced in nearly all parts of the world, perhaps in the largest amounts for commerce in Europe and Africa.

**Spermaceti.** Spermaceti is a wax which occurs chiefly in the head cavities and the blubber of the sperm whale (*Physeter macrocephalus*). Most of the commercial article is the solid residue from cooled and filtered whale oil. It is used in making candles, in pharmacy, and for waxing cartridge covers.

## ESSENTIAL OILS AND OTHER PERFUMES

Essential (fragrant or volatile) oils are unlike the fatty oils in their composition. They are fluids which evaporate on exposure to air, they sometimes feel somewhat greasy, and they do not form soap when treated with alkalies. They are chiefly characterized by their powerful odors and are in many cases the actual cause of the aroma and taste of vegetable substances, such as spices. Essential oils are derived from whole plants or from the specially fragrant parts, such as flowers, leaves, bark, fruit, seed, etc.

Many essential oils are obtained by distillation. The substance which contains the fragrance is put in a large closed tank and covered with water, heat is applied, and the steam which forms is carried away by pipes. It takes with it the volatile oil in a state of vapor. The pipes pass through a cooler, where the steam and the vapor condense, and the oil floats on the surface of the water. The volatile oil can be skimmed from the water and purified.

Some volatile oils are injured or destroyed by distillation. These are separated by other methods. Some are obtained by expression; for example, the fragrant oils from the rinds of lemon, lime, and orange fruits are obtained by rubbing the skin against a sponge, which absorbs the oil, or by rolling the fruit gently over upright needle points, which break the cells containing the oil.

Oils from flowers are particularly volatile and are frequently absorbed by soaking the blossoms in warm lard or beef fat. This process is called enfleurage, and the fat containing the perfume is called pomade, a commercial article of much importance to perfume-makers. The fragrance is dissolved from the fat by means of alcohol.

Many essential oils are made artificially from a coal-tar base. Among the best known of these are artificial oil of wintergreen (methyl salicylate) and oil of bitter almonds (benzaldehyde). The artificial preparations duplicate the scent of almost all flowers and the taste of almost any desired fruit, of cinnamon or other spices, or of such flavorings as vanilla.

The preparation of essential oils from flowers for perfumery is a very important industry in the south of France and in the French colony of Réunion. There is an important production of perfume oils in India and the Far East. In the United States the manufacture of peppermint oil is the leading industry in this class, New York and Michigan being the largest producers.

Essential oils are used in the manufacture of perfumes and toilet waters, for flavoring foods and drinks, and in medicine.

A recent development in the use of essential oils is the separation of metallic compounds from their ores by the flotation process. Some of the cheaper volatile oils are used on mops for household cleaning and polishing and as a spray to lay dust.

Among the many volatile oils the following are important:

From flowers: Rose, known as attar or otto of roses (from Bulgaria, Persia, Turkey, India, France, etc.), violet, tuberose, lilac, heliotrope, lily, hyacinth, carnation, sweet-pea, jasmine, jonquil, lavender (from southern France), aspic, ylang-ylang, or cananga (from the Philippines and Java), neroli, or orange-flower (from southern France and Italy), frangipani, etc.

From leaves: Bay (*Pimenta acris*) for making bay rum (produced chiefly in small islands of the West Indies), mint, peppermint (from Michigan, Ohio, New York, Russia, France, Italy), menthol, spearmint, wintergreen, thyme, sage, rosemary, geranium, rose-geranium, pennyroyal (from the United States and France), patchouli, citronella (*Andropogon*, from Ceylon and Java), lemon-grass, petitgrain (*Citrus bigardia*), cajeput (*Melaleuca leucadendron*, from the East Indies), wormwood (used for flavoring absinth), pine-needle (spruce, hemlock, and cedar leaf from the northeastern part of the United States), eucalyptus (from Australia and California).

From roots: Vetiver (vetivert, cuscus, or kuskus), calamus, ginger, orris, nard (or spikenard), sassafras (chiefly from Tennessee).

From fruits or seeds: Anise, allspice, caraway (carvol), cumin, dill, mustard, nutmeg, mace, coriander, cubeb, fennel, cardamom, star-anise, clove, almond, bitter-almond (from bitter-almond, peach, or apricot kernels), juniper berry. From the rinds of citrus fruits: orange (from Sicily and Jamaica), bergamot (from Sicily and Italy), lemon (from Sicily), citron, petitgrain, lime.

From bark: Cinnamon, cassia (chiefly from China), witch-hazel.

From wood: Cedar (a by-product of the lead-pencil industry), pine, juniper (or cade), savin, birch (from North Carolina and Pennsylvania), sandalwood, bois de rose, guaiac wood, linaloe (from Mexico), amyris (from Venezuela), camphor, camphor oil, safrol, birch, wood turpentine.

From sap: Turpentine, rosin spirit, amber oil.

The leaves, roots, seeds, barks, and woods referred to above are nearly all of them standard articles of commerce.

**Turpentine.** Crude turpentine is a semifluid, sticky oleoresin exuded from wounds made in the trunks of several trees belonging to the pine family. It is produced chiefly in the United States, Finland, Russia, Austria, France, Spain, and India. In the United States it is obtained almost exclusively from the longleaf, or yellow, pine (*Pinus palustris*), in India from the Himalayan pine (*Pinus longifolia*), and in Europe from the Scotch pine (*Pinus sylvestris*, *P. maritima*).

Turpentine is usually obtained by removing a wide strip of bark on one side of the tree and cutting below this into the wood to form a pocketlike cavity known as a box. The wound thus made discharges the fluid into the pocket, which holds two or three pints and is filled in about ten days. The crude turpentine is then dipped out and the wound reopened to stimulate a further flow. By more modern and careful methods the trees are not ruined by the removal of so large a strip of bark and are not weakened by the cutting of the box, since the turpentine is caught in vessels which are hung on the side of the trees. In this way the yield of turpentine is increased and the life of the tree lengthened. The crude turpentine, which consists of resin dissolved in a volatile oil, is put into a still with water and distilled. The steam goes through the pipes, carrying the volatile oil with it, and the distillate is allowed to cool in a vat. The water and oil separate into two layers, and the latter is drawn off in barrels for market. It is known as spirits of turpentine, oil of turpentine, or turps. Strictly speaking, it is a volatile oil and is commercially very much more important than any other substance of the class. It is largely used in mixing paints and in dissolving resins for varnishes. It is a solvent for rubber and is used in medicine and in veterinary practice as a liniment. (See Venice turpentine, under Oleoresins.)

It is stated that much Russian turpentine is the product of the distillation of pine wood and is not obtained by tapping

trees. Similarly, there is a great deal of "wood turpentine" produced in the United States by distilling yellow-pine stumps, knots, and "fat" pine wood.

Turpentine is graded commercially according to its color, from the best "water-white" downward. It is sometimes adulterated, and there are various substitutes offered. The most important of these are volatile distillates of petroleum and mixtures containing rosin spirit.

The residue remaining in the still after the turpentine has been driven off is a solid resinous substance of an amber or blackish-brown color, known as rosin, pine resin, or colophony.

Rosin spirit is obtained by the destructive distillation of pine resin. It has much the same nature and qualities as turpentine.

**Camphor.** Camphor, often called gum camphor, is really a solid volatile oil, distilled from the wood of the camphor tree (*Cinnamomum camphora*). The commercial supply is nearly all from Taiwan (Formosa). Smaller amounts are prepared in Japan and China. The tree is cultivated in many places, and there is a small production of camphor in Florida, distilled mostly from leaves, twigs, and smaller branches. Borneo camphor (borneol) is from another tree. Artificial, or synthetic, camphor is sometimes made by chemical processes.

The chief use of camphor is for making celluloid, smokeless powder, and high explosives. It is used also in medicine and to protect clothing from insects.

Safrol is separated in purifying camphor and is also obtained from sassafras oil. It is used for flavoring and in medicine. Camphor oil is another by-product useful in mixing paint.

See also tar camphor, or naphthalene, under Coal.

**Menthol.** Menthol is formed in crystals during the cooling of peppermint oil. It is produced chiefly in Japan and is used in medicine and in flavoring chewing-gum.

**Clove oil.** Clove oil is an essential oil distilled from cloves, clove stems, and mother cloves. It is used for flavoring, for

perfumery, in medicine, and in dentistry. One of its most important uses is as a base for a vanilla substitute.

**Gum resins.** Myrrh, benzoin, frankincense, and opopanax are fragrant gum resins valued for their aroma.

A few perfumes are from animal sources.

**Ambergris.** Ambergris is a fragrant substance formed in the intestines of the sperm whale (*Physeter macrocephalus*). It is used as a basis for perfumes and commands a very high price.

**Musk.** Musk is from a small sac in the body of the male musk deer (*Moschus moschiferus*), which lives in the mountains of Tibet, China, India, and Siberia. The musk ox and the musk rat produce a similar substance.

**Civet.** Civet is from the civet cat (*Viverra civetta*) of Africa and Asia.

**Castoreum.** Castoreum, from the beaver (*Castor canadensis*), is used for perfume and medicine.

# FIBERS

Fibers are classed commercially, according to the use for which they are suitable, in the following groups:

1. Textile fibers, including all which can be spun and woven. The best grades of many cordage fibers fall into this group as well as some grades of asbestos, many metal wires, and tinsel.

2. Cordage fibers, suitable for rope and twine. In order of importance the chief are Manila hemp, Yucatan henequen or sisal, and New Zealand hemp.

3. Brush fibers, usually too stiff for spinning. Many are special qualities of fibers in the preceding groups.

4. Felting, chiefly animal fibers.

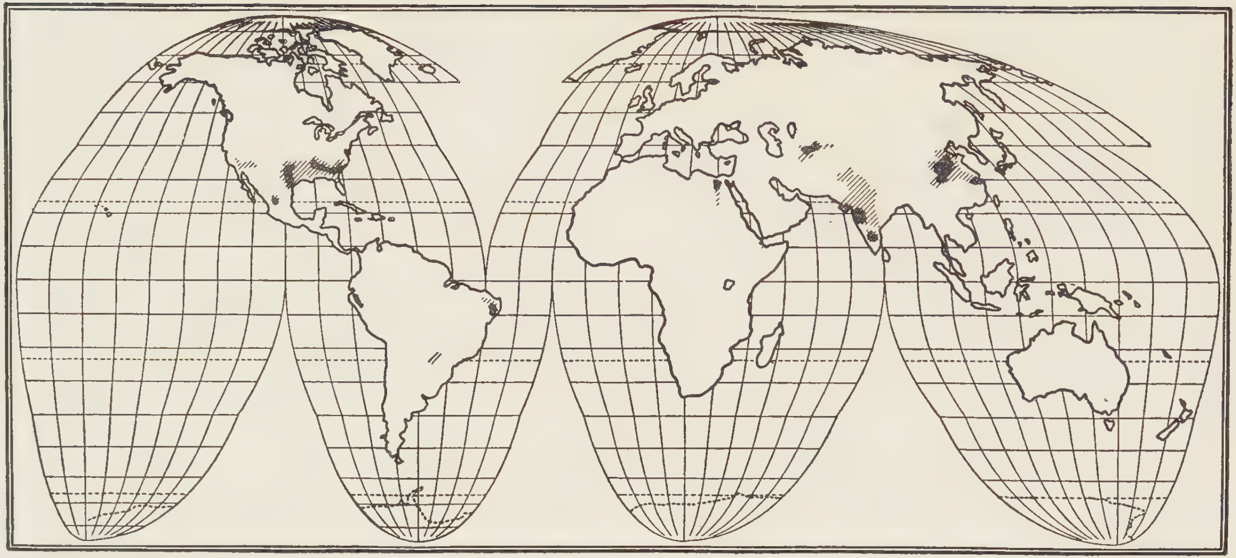
5. Upholstery, mostly fibers which cannot be spun into good yarns. We may include here or in the preceding group such fibers as are used for fireproofing, for deadening sound, and for similar purposes.

6. Paper-making.

Another classification, thought by some to be more scientific, is based on the origin of the fiber:

I. Vegetable fibers:
   1. Plant hairs, such as cotton.
   2. Bast fibers, such as flax.
   3. Structural fibers (usually from leaves, leaf stalks, or bracts), such as Manila hemp, sisal, piassaba, etc.
   4. Fibers from fruit husks, such as coir.
   5. Whole stems or parts of plants, such as wood, rattan, Spanish moss, seaweed, etc.
   6. Artificial fibers, such as artificial silk.

II. Animal fibers:
   1. Hair, wool, and fur.
   2. Silk.



Goode's Homolosine Projection

FIG. 21. Areas of Cotton Production

Cotton is grown most extensively in subtropical regions. In India the cotton districts, though mainly tropical, are from one to two thousand feet above sea level

III. Mineral fibers:

1. Natural: asbestos.

2. Artificial: mineral wool, metal wires, tinsel, etc.

**Cotton.** Cotton, the most important vegetable fiber, consists of the hairs which grow out from the seeds of the cotton plant (*Gossypium* sp.). Cotton plants usually grow to a height of from two to four feet. In places free from frost some varieties grow fifteen feet high. The bolls, or seed pods, ripen more or less continuously for a season usually of several months' duration. The field must therefore be picked over repeatedly, the gathering being done by hand labor. The unginned, or seed, cotton goes to the cotton gins, where the fiber and the seed are separated. An ordinary ginning machine has seventy circular saws, each six or seven inches in diameter, set near together on a shaft. The edges of these saws project through slots in a grating into a box which holds the seed cotton. The slots are so narrow that the seeds cannot pass through. When the saws revolve, their teeth catch the fiber and pull it away. Rapidly turning brushes take the cotton off the teeth, and it is blown through pipes to a cotton press, where it is packed in bales. American upland cotton is cleaned by saw gins; Egyptian and other long-staple cottons are separated from the seeds by roller gins, which do less damage to the fiber and leave it in better condition for fine spinning.

The American square cotton bale is 56 inches long, 28 inches wide, 42 inches thick, and weighs 500 pounds. For transportation to distant mills these bales are so compressed that they remain the same length and width but become only 18 inches thick. This makes it possible to pack more than twice as much on a freight car or a steamship. A small part of the cotton crop is packed in cylindrical (round lap) bales.

More than half the cotton produced in the world is raised in the south Atlantic and Gulf states of the United States. India, China, Egypt, Brazil, Peru, and Mexico are the other leading cotton-producing countries. Before the World War

parts of Turkestan were important for their cotton production. There was a considerable decline in production after that time, however, although the amount grown is now increasing.

- COTTON PLANT
  - Cotton
    - Yarn
      - Cordage
      - Fabrics, rags
        - Paper
        - Parchment paper
        - Vulcanized fiber
    - Cotton waste
    - Linters
      - Batting, upholstery
      - Absorbent cotton
      - Alkali cellulose, artificial silk
      - Nitrocellulose
        - Explosives, guncotton
        - Celluloid
        - Artificial silk
  - Seeds
    - Cattle food
    - Oil
      - Table oil
      - Cooking-fat
      - Hardened oil, oleomargarine
      - Cottonseed stearin
      - Glycerin, dynamite
    - Oil cake: meal, cattle food, fertilizer
    - Hulls: paper stock, cattle food, fertilizer, fuel
  - Stalk: contains bast fiber; can be used for paper-making
  - Root: medicine

Cotton is not yet of any great commercial importance in Africa, except in Egypt; but conditions are good for its development in many parts of the continent, and an appreciable amount is already produced in the Sudan and Nigeria, in the protectorates of Uganda and Nyasaland, and in other sections.

An ordinary cotton crop in the United States amounts to perhaps twelve million bales, of which this country manufactures about 45 per cent and exports about 55 per cent to England, Germany, Japan, France, Italy, and other countries. Liverpool is the largest world market for cotton. The greatest cotton exchanges in the United States are in New York, Galveston, and New Orleans. The greatest centers of cotton manufacture are Lancashire (England), the New England States, the Carolinas, and Georgia. Germany, France, Italy, Russia, India, and Japan are also important consumers of raw cotton.

Cotton fibers vary in length in different cultivated varieties. Sea-island cotton has the longest staple, from an inch and three fourths to two inches. It is grown on islands off the coast of South Carolina, in Georgia and Florida, and in St. Vincent, the Leeward Islands, Grenada, Barbados, and other West

FIG. 22. Shipping Cotton, Savannah, Georgia

Compressed bales are unloaded from the freight cars and brought by trucks from warehouses. Each bears its mark, and an inspector checks them up as they are sorted into piles, some destined for factories in New England, some for English mills, and others for Japanese mills. Cotton varies in quality and therefore in price, so it is important that every buyer get the bale of cotton he bought and of which he examined a sample

Indian islands. It can be spun into the finest yarns up to No. 400. This actually means that one pound of sea-island cotton may make a single yarn 190.9 miles long. This kind of cotton makes the strongest yarns and consequently is used in the manufacture of the best cords for automobile tires. It is used for spinning sewing-thread and in yarn for laces, etc.

Egyptian cotton has fibers about an inch and a half long. It is raised on irrigated land, mostly in the Nile delta. It is used in the United States largely for making hosiery and underwear and for mercerizing, and it also goes into fabrics for automobile tires, especially in Europe. There are several important cultivated types of Egyptian cotton, known as Sakellarides, Afiffi, etc. Much of the Egyptian cotton is of a creamy tint. It generally comes in 700-pound bales.

Peeler cotton, from the Mississippi River region, is usually a trifle less than an inch and a half long; gulf cotton, from lowlands near the Gulf of Mexico, is a little over an inch in length. Any American cotton over one and one-sixteenth of an inch is called staple cotton and brings a better price than upland.

Upland cotton forms the bulk of this country's crop. It has a length of from seven eighths of an inch to one inch. Brazilian cotton is mostly short and rather rough. Indian and Chinese cottons are also of poor quality.

The price of raw cotton depends first of all on its staple, sea-island cotton selling usually for from two to three times as much as the upland variety. Upland cotton is bought and sold on the basis of its official "grade." This means that a sample from every bale is examined carefully with reference to its color and its freedom from fragments of leaves and dirt. On this basis it is classed under one of the following names, which correspond with standard samples authorized by the United States government: (1) "middling fair"; (2) "strict good middling"; (3) "good middling"; (4) "strict middling"; (5) "middling"; (6) "strict low middling"; (7) "low middling"; (8) "strict good ordinary"; (9) "good ordinary." Market quotations are based on middling (grade 5), and the price is a little more or less per pound as the bale is classed above or below that grade.

Peruvian cotton is a peculiar variety with a rough feel. It varies from brown to white in color. Its chief use is for

mixing with wool, and its price has almost no reference to that of other kinds of cotton.

Sea-island cotton comes away from its seeds freely; but after upland cotton is ginned, many short fibers remain attached to the seeds. These, down to the very shortest (less than a sixteenth of an inch in length), are removed by special gins and constitute linters. The longest linters are fully as long as the poorer varieties of cotton and are used in spinning cheap yarns. Shorter grades go into mattresses, cotton batting, wadding, quilts, horse collars, etc. Clean grades of linters and cheap qualities of cotton fiber are specially sterilized and treated to make absorbent cotton. The very shortest linters are often called delint. Cotton is a very pure cellulose, and since linters are the cheapest form of cotton they are often used as a base for the manufacture of artificial silk, guncotton, and celluloid.

Cotton is remarkable for its spinning quality. When a few fibers are twisted they cling together and readily draw others after them. In this they differ from the seed hairs of other plants. The explanation of this is seen under a microscope, where a cotton fiber appears as a long, naturally twisted cell. The hairs of other plants are not twisted and therefore do not cling to each other when attempts are made to spin them.

In a cotton mill the bales are opened, and the raw cotton is loosened up and spread out by machinery. It passes through a series of machines that pick it and clean it of all dirt, card it on great rollers covered with sharp wires, and transform it into a long, loose, ropelike sliver. If it is long-staple cotton, the next operation is combing, to make the fibers lie smooth and parallel. Then other machines draw and twist it into a slubbing, next into an intermediate, and then into a roving, each longer and more slender than before. The rovings are spun into yarn on swiftly revolving spindles. There are 840 yards of cotton yarn in a hank, and if 8 hanks weigh a pound, the yarn is No. 8; if there are 40 hanks in a pound, the yarn is No. 40.

The United States manufactures enormous quantities of the coarser cotton fabrics and has a large export trade in unbleached muslins. It is true that this country turns out fine cotton fabrics also, but we import very large amounts of fine cotton goods from France and England as well as cotton laces and embroideries from Switzerland and France.

Cotton fabrics are made by weaving or knitting. The latter process has developed remarkably with improvements in machinery. The important cotton fabrics are too numerous and too varied to be enumerated here. They can be grouped, according to use, into dress goods, suitings, hosiery, underwear, ornament, household uses, and industrial purposes. In these groups we find all kinds of weaves and materials adapted to an infinite variety of purposes. Many fabrics are woven of mixtures of cotton with linen, silk, or wool. Fabrics are dressed, loaded, or given "body," by starch, dextrine, gum arabic, clay, and various other substances.

Mercerizing is a process applied frequently to yarns spun from Egyptian or sea-island cotton and sometimes to woven cotton fabrics. It consists in treating the cotton with a solution of caustic soda. This causes the cotton to shrink; but in practice the yarns are washed and dried on reels, which hold them stretched, thereby preventing shrinkage. The result of the process is a yarn that is decidedly stronger, that has a luster like silk, and that is easier to dye. Other fibers, such as flax, are sometimes mercerized.

Cotton waste consists of the more or less tangled or knotted ends of yarn or partly spun cotton. It forms when short pieces are pulled off now and then if a roving or other strand breaks and the machine is rethreaded. A little of this waste is worked over and spun into cheap yarns, but large quantities of it are used for wiping machinery. Cotton rags are used for paper stock.

Guncotton, a powerful explosive, is prepared by treating cotton waste or linters with a mixture of sulphuric and nitric

acids. Collodion, valuable in surgery and photography, is a solution of guncotton in ether and alcohol.

The utilization of cotton seeds and all their by-products has added immensely to the wealth of the United States, has made cotton a more valuable crop to the farmer, and has given a very large amount of useful products to humanity. The value of the cotton seeds produced annually in this country is perhaps one eighth as much as the value of the raw cotton.

**Kapok.** Kapok, or silk cotton, is a cream-colored seed hair from pods of a large tree (*Ceiba pentandra* or *Eriodendron anfractuosum*). Most of this fiber on the market comes from Java. It is largely used in upholstery and in life-preservers. The seeds yield a semidrying oil. Similar fibers are produced by various "cotton trees" in the tropics (*Bombax* sp. and *Ochroma* sp.), but most of these are less elastic, browner in color, and shorter in staple than kapok.

Pochote of Mexico and Central America is a short, soft, brown fiber from the pods of a large tree (*Ceiba acuminata*). The seed hairs of milkweeds (*Calotropis* etc.) are similar to kapok.

The fibers of all these silk cottons are so smooth and straight that they cannot be successfully spun into a satisfactory yarn. Fabrics on the market called by similar names are usually made of artificial silk.

**Pulu.** Pulu, from the Hawaiian Islands, is a soft, brown fiber consisting of hairs from the bases of tree ferns. It has been used in upholstery and as a styptic in medical practice.

**Flax.** Flax is the most important bast fiber in use, because it grows well in temperate climates, can be extracted and cleaned without great difficulty, is strong, and can be bleached perfectly white without being weakened. It is easily spun and woven into coarse, heavy textiles or fabrics of exquisite fineness. It is durable and washes well.

Flax plants (*Linum usitatissimum*) are raised for two distinct purposes: the production of fiber and the production of seeds (see Linseed oil). The plants which produce good com-

mercial fiber are tall (about three feet or a little more), straight, and with few branches. The plants raised for flax seed, on the other hand, have many branches with seed pods. In normal times Russia produces more than half the world's supply of flax fiber, but it is inferior in quality to that raised in Belgium (especially in Courtrai) and northeastern France. Russia, Poland, Esthonia, Latvia, Lithuania, Belgium, France, Czecho-slovakia, Austria, Hungary, Italy, Ireland, and Japan are important growers of flax for fiber. A little is produced in the states of Michigan and Minnesota and in the region of Puget Sound.

When flax plants are raised for fiber, they are not cut but are harvested by being pulled up, root and all. Thus the fibers are retained as long as possible. The seeds are then thrashed out, or rippled, by drawing the stems through the teeth of an iron comb. These seeds are used for making linseed oil, but are of inferior quality.

To separate the fiber the stalks (stems or straw) are retted. Retting is a process of slow and partial decay which softens and loosens the bark and the woody part of the stem. If carefully watched, the decay does not go far enough to affect the strength of the fiber. Pool-retting is done by tying flax stalks in bundles and sinking them in pools or slowly flowing streams of soft water. The bundles are taken out and dried, and the process is repeated several times. The best flax fiber is pool-retted in Belgium. In Russia a great deal of flax is dew-retted, which means that the process of softening the stalks is accomplished not by immersion in water but by spreading the stalks out on damp meadows and exposing them to the dew and rain.

Some flax is artificially retted by two different types of process, but as yet these are not so successful as to bring them into general use. One process depends on bacterial fermentation in tanks to soften the stalks and loosen the fiber; the other uses weak acids, alkalies, or other chemicals to decompose the straw.

Great quantities of flax straw are destroyed annually in this country in Minnesota and North Dakota, and in India and other places where flax seeds are grown. Attempts are made from time to time to utilize these stems. The fiber obtained from them, however, is by no means equal in quality to good grades of flax, and the use of it is at present limited to the manufacture of floor rugs and very coarse fabrics. Only a negligible percentage of such flax straw is utilized at all.

FIG. 23. Hackling Flax in Belgium

A comb composed of sharp steel points is fastened firmly to the stool. The woman pulls a handful of flax through this comb, thus straightening out the tangles, removing broken fibers, and splitting the coarse strands into fine ones. She is using a very coarse comb for a first rough dressing. Finer combs must be employed before the fiber is ready for spinning

If it were possible to harvest flax plants by machinery instead of pulling them by hand, and then to ret the stalks in tanks in a factory instead of by hand labor, it might be possible to produce this fiber in the United States.

After retting, the stalks are dried and broken by pounding, and then scutched, or beaten, to remove the scraps of wood and bark (shives). The breaking and scutching are done by hand in Russia and by machinery in Belgium. The result of these processes is the commercial fiber as it ordinarily comes to the mill, packed in bales made up of small

bundles of flax. Fiber of good quality is long, fine, straight, glossy, and light in color.

The next process is hackling, or combing, which separates the long fibers (line) from the short fibers (tow) and straightens out the best fiber ready for spinning. Hackling is done by drawing the flax through sharp steel pins like a series of combs. The pins, or teeth, of a coarse hackle may be three inches long and half an inch apart; a fine hackle has teeth as slender as small needles set very close together. Modern mills use hackling-machines to do much of this work, but a great deal of hackling is still done by hand, especially the preliminary work and the final dressing of the finest fiber for the smallest sizes of yarns.

Flax is spun by two processes: wet and dry. All the finest machine-made yarns are spun wet, which means that the strand is drawn through a trough of hot water just before the final twisting. Machines spin linen yarn as fine as No. 200. Hand-spun linen yarns are sometimes made as fine as No. 600. These latter may sometimes be seen in the most costly Belgian laces.

There are few linen mills in the United States, this line of manufacture being confined largely to Europe. Belfast, Ireland, makes a large percentage of the finest linens of the world. Climatic conditions for bleaching linen fabrics are perhaps nowhere else so favorable. Irish mills use a great deal of Belgian flax. France, Belgium, and the countries adjacent weave much linen and have commonly been dependent for their supply of fiber on Russia as well as on their own production.

**Hemp.** Hemp is a name applied to many different fibers, and it is often preceded by some descriptive term; for example, Manila hemp, sisal hemp, etc. True hemp is a strong bast fiber from a plant (*Cannabis sativa*) which grows from six to ten feet tall, with stems as thick as a man's finger. Russia, Italy, France, Germany, and Hungary are the important producing countries. Some comes from other parts of central Europe. India, China, Japan, and Chile also raise this fiber. Some

fiber is produced in Kentucky, Wisconsin, Michigan, Indiana, Ohio, and California. The best and finest hemp (Italian) is extracted by pool-retting; low-grade fiber (American hemp) is separated by dew-retting, followed by machine cleaning.

Commercial hemp fiber is longer and coarser than flax but not so strong, and it cannot be bleached perfectly white. It is important for the manufacture of commercial twine and other cordage. Some goes into warp yarns for good carpets. It is used for sailcloth and bagging. The best qualities of Italian hemp are so fine and light in color that they are woven in fabrics that look like coarse linens. Hempen homespuns were much worn by the peasantry of Europe a few hundred years ago and even till recent years in western France.

The seeds of hemp yield oil, and the leaves and tops a narcotic.

**Jute.** Jute is a cheap bast fiber from a tall, slender plant (*Corchorus* sp.). The chief commercial supply is from Calcutta, India. It is raised very largely in the province of Bengal and the adjacent country as far north as Nepal and eastward into Assam. The fiber is long, lustrous, soft, and easy to spin into coarse threads. It is much weaker than hemp, is difficult to spin into fine threads, does not bleach well, and loses in strength with age or when exposed to dampness. It is used for bagging, as a covering for cotton bales, and for burlap (called hessians in England), gunny cloth, twine, and rope. Carpet warps are commonly of jute, and it goes into cheap plushes and other fabrics. The greatest centers for jute manufacture are Dundee, Scotland, and Calcutta, India.

**Ramie.** Ramie, or China grass, is the bast of a tall plant of the nettle family (*Bœhmeria nivea*). It is cultivated in southern China and adjacent regions, and to a small extent in other parts of the world. This fiber has remarkable merits. It is very fine and very strong, is long, white, and lustrous when properly cleaned, is light in weight compared with linen, and the production per acre is large since the plant is more than twice

the height of flax. There grows with the fiber, however, in the inner bark of the plant, a gummy substance which is not removed by such retting as flax receives and which resists many chemical methods that have been tried to clean the fiber.

Fig. 24. Jute Harvest in Calcutta, India

The delta region of the Ganges River is the chief source of jute. The plant grows easily in this great area of swampy land, and the low price of labor makes the industry successful

Raw ramie consists of the dried bast still containing the gum. It is imported to various European factories and in small amounts to the United States. The processes for cleaning it have apparently not been cheap enough to make ramie a successful competitor of linen or cotton. The clean fiber is made into velvets and underwear, but it is especially used for the knitted material which is the base for incandescent gas mantles.

Ramie, cleaned at the expense of much time and hand labor, is used in China for clothing and cordage. Canton linen, or Chinese grass cloth, is a ramie fabric. It used to be woven entirely by hand, but as it has grown in popularity power looms are now employed.

**Minor barks and fibers.** Nettle fiber is the bast of the common stinging nettle of Europe (*Urtica dioica*). It is a strong, fine, white fiber comparable to linen and cotton, and was utilized in Germany during the World War.

Pita and tronadora (*Abutilon triquetrum*) are basts used considerably in Mexico.

Sunn hemp (*Crotalaria juncea*), ambari hemp of India, and various other basts are of minor importance.

Russian bast is the inner bark of the European linden, or lime, tree (*Tilia* sp.). It is used locally in Russia and central Europe for mats, bags, ropes, etc.

Cuba bast is a particularly beautiful lacy bast (*Hibiscus elatus*) prepared in large thin sheets and used chiefly for tying cigars and in millinery.

Lacebark (*Lagetta lintearia*) is an ornamental bast prepared in Jamaica.

**Manila hemp.** Manila hemp, or abacá, is the strongest rope fiber in common use. It is obtained in the Philippines from the leaf stalks which form the apparent trunk of a tree (*Musa textilis*) of the banana family. This tree is like the common banana tree except that the leaves are a little narrower and it does not produce edible fruit. To obtain the fiber the tree is cut down, the leaves are removed, and the leaf stalks are separated and scraped with a dull knife till all the pulpy part is cleaned off. The coarse fibers which remain are then washed, dried, and made up into bales. They are longer than any other commercial fibers (up to twelve feet). Manila ropes and twines are very little harmed by either fresh or salt water. Selected manila-hemp fiber is worked up, chiefly by machinery in Japan and the Philippines, into Tagal hat braids

used in Europe and America for millinery. The Filipinos weave fine fibers by hand into sinamay cloth.

All banana plants contain an immense amount of fiber in their stems, but in spite of many experiments there is no real commercial use of any except the above.

**Agave fibers.** Many species of agave plants grow in Mexico and Central America. One variety that we know in the United States is called the century plant because it is popularly supposed to bloom once in a hundred years. In its native climate some varieties of agave bloom in three years; others take as much as ten or fifteen years to mature. These plants all have fleshy leaves, in which nature has placed strong fibers to strengthen and stiffen them. The fiber is cleaned by scraping away the pulp, either by hand or by machinery. Many species yield fiber for local use in rope, bagging, brushes, and hammocks. The product is called by many names, according to the locality and the variety of the plant which produces it; for example, henequen, sisal, maguey, lechuguilla, ixtle, pita, yaxci, zapupe, hemp, etc. The names are rather loosely applied by the natives, the same fiber being called by different names in different places. A few varieties are commercially important.

**Henequen.** The name "henequen" is applied in different places to fibers of very different qualities. The most important is Yucatan henequen, or sisal hemp (*Agave fourcroydes*, *A. rigida elongata*), which is exported in large amounts from the port of Progreso, Mexico. It is produced in smaller quantities in the state of Sinaloa and in Cuba. In the United States henequen is the most important fiber for binder twine and is much used in rope. Its merits are its length (up to five feet) and strength. Good qualities are of a very light straw color, hard, wiry, and elastic, but not brittle. This fiber is commonly called sisal.

**Sisal.** True sisal comes from a different species of agave (*A. sisalana* or *A. rigida sisalana*), a plant originally native in Mexico but now cultivated mostly in Java, Madura, East Africa,

and the Bahamas. Some is produced in Jamaica, Central America, and Florida. The fiber is usually considered inferior to Yucatan henequen.

**Maguey.** Maguey fiber is much used locally in Mexico but is seldom exported. It is from several species of agave. Philippine maguey, Manila maguey or Manila aloe (*Agave cantula*), is a strong fiber produced in fairly large quantities from cultivated plants. Bombay aloe and Java maguey are similar. These fibers average from three to four feet in length.

**Ixtle.** Ixtle is a shorter fiber (up to twenty inches) from plants with smaller leaves. Much of it is from northeastern Mexico. Jaumave ixtle, or lechuguilla (*Agave funkiana*), and Tula ixtle (*Agave lecheguilla*) are important. These sometimes are marketed under the names of "Tampico hemp," "Tampico fiber," or "sea grass." These fibers are used for making brushes and for preparing a substitute for curled hair in mattresses and upholstery.

**Other leaf fibers.** Fibers shorter than henequen, sisal, and maguey are obtained from fleshy-leaved plants of other species, such as the yucca, the aloe, and the pineapple, but these are not of very large use in the world of commerce.

Many yucca fibers are marketed but in relatively small amount. Among them are *palma pita* (*Yucca treculeana*) and *palma ixtle* (*Samuela carnerosana*) from northern Mexico and in very small quantity from the southwestern United States.

Pineapple fiber from the fleshy leaves of the cultivated pineapple plant (*Ananas sativa*) is prepared in the Philippines and is used for weaving remarkably fine dress fabrics (*piña* and *jusi* cloths). Similar fibers are used in a small way in Taiwan (Formosa), Borneo, and elsewhere in the South Pacific. In southern Mexico a pineapple fiber (*Ananas macrodontes*) is known as *pita floja*. Great quantities of wild plants similar to the pineapple (*Bromelia* etc.) grow in many tropical countries. The fibers which can be extracted from these have large potential value. When prepared experimentally they are remarkably

FIG. 25. Henequen Harvest in Yucatan, Mexico

A few leaves are cut each year around the base of each plant. This induces a rather unnatural treelike growth. Yucatan sisal, or henequen, cleaned from the fleshy leaves of these plants is the standard fiber for binder twine. This industry therefore is closely connected with the wheat harvest and our daily bread

fine, strong, and lustrous, seeming to rival silk and linen. Up to the present time these fibers are of only local use.

Mauritius hemp is from a plant (*Furcræa fœtida*) of the lily family, a native of eastern Brazil, but cultivated chiefly on the island of Mauritius. This is an important rope fiber.

Many more plants of the lily and other families have fleshy leaves which contain structural fibers.

Cabuya fiber, sometimes called Central American sisal, is produced in Costa Rica from a similar plant (*Furcræa cabuya*). It is not marketed in very large quantities, but when well prepared it is both long and strong. Cuban hemp and Venezuelan cocuiza are similar.

New Zealand hemp, or New Zealand flax, another excellent rope fiber, is from the long fleshy leaves of a wild plant (*Phormium tenax*). The commercial fibers are often eight feet long.

Bowstring hemp (*Sansevieria guineënsis*) of Africa and several other less important fibers belong in this same group.

**Coir.** Coir, coco or cocoa, fiber is obtained from the husks of the coconut (*Cocos nucifera*). The husks are soaked in water until they are sufficiently softened; then they are torn apart, and the fibers are separated and cleaned. Commercial coir is a coarse, stiff, springy fiber. Much of it is somewhat curly and is used for upholstery and for weaving in cocoa matting. One quality is used in the bearings of railway cars to feed oil to the axles. The best grades are straight fibers, which grow as much as ten inches long and are used in making brushes. Ceylon and Singapore are the principal exporters of coir. Throughout tropical Asia and the South Pacific islands coir is extensively used for cordage, even for ships' hawsers.

**Piassaba.** Piassaba, piassava or bass, is a coarse, stiff fiber used for making brooms and brushes, especially for street sweeping. It often reaches a length of four feet, varying in diameter from one thirtieth of an inch to one sixteenth. The commercial varieties are known as West African and Brazilian

(Bahia and Pará). They are obtained from the fibrous sheaths which grow round the leaf stalks of certain palm trees.

West African bass comes from the tree (*Raphia vinifera*) which yields a leaf fiber similar to raffia. The sap of this tree is used by the natives in making wine. Bahia piassaba comes from a different palm (*Attalea funifera*), and Pará bass from another (*Leopoldinia piassaba*).

**Kittool.** Kittool, or kittul, is a finer brush fiber from the leaf sheaths of a Ceylon palm (*Caryota urens*). Palmyra fiber, or bassine (*Borassus flabellifer*), is from India. Arenga fiber (*Arenga saccharifera*), from the East Indies, is practically identical with Philippine cabo negro and Chinese coir. This fiber in its finest qualities resembles black horsehair.

**Palmetto.** Palmetto is obtained in our Southern states from the leaf stalks and creeping stems (commonly called the roots) of the saw palmetto (*Serenoa serrulata*). This plant is rich in tannin and is an important source of tanning extracts (q.v.). The fiber is the spent material from which the tannin has been extracted. The tangled fiber is used for mixing in plaster and sometimes for paper stock. Some straight fiber is sorted out for brush-making; on account of its close resemblance to coconut fiber it is sold under the name of "palmetto coir." This palmetto grows wild in the Gulf states, and its leaves are utilized in making artificial palms, commonly used for decoration.

**Raffia.** Raffia, or raphia, fiber from Madagascar is used principally by gardeners for tying plants. It consists of strips of skin peeled by hand from the surface of the leaflets of a palm tree (*Raphia pedunculata*). It is used for making mats, for basketry, for fancy articles, and, by the natives, for weaving cloth. There is a small export of hand-woven raffia fabrics (rabannas) from Madagascar. A similar raffia palm yields a fiber used locally in West Africa.

**Other palm-leaf fibers.** Panama straw for making Panama hats is prepared by splitting, cleaning, and bleaching the young leaves of the jipijapa palm (*Carludovica palmata*). It is pro-

duced in northwestern South America, Central America, and the West Indies. Various other split palm leaves and pandanus leaves yield "palm straw" similar in appearance. The most important are pandanus straws, which are used for making hats in Taiwan (Formosa), Japan, Siam, and the Philippines.

Split palm leaves are much used in tropical countries for weaving matting and for making baskets.

Crin végétal is the shredded leaves of a small palm (*Chamærops humilis*). It is imported from Algeria in the form of ropes and, when opened up, is used in upholstery.

The midribs of palm leaves are often used locally in making brooms and brushes. There is an increasing export of such fiber from the Far East to America and Europe to be used in the manufacture of brooms and brushes for the hardest wear.

**Straws and stalks.** Straw, chiefly of wheat and rye, is used in making hat braids. The principal centers of manufacture are northern Italy and southern China. Various straws are used for paper-making, packing-material, upholstery, bedding for live stock, thatching, mattings, etc. Other straws are used in paper-making, especially as a base for strawboard.

Rushes (*Juncus* sp.) are used for chair seats, baskets, hats, and so on.

Matting, made from the dried stems of a sedge (*Cyperus* sp.), is an important export from Japan and southern China.

A hard, wiry sedge (*Carex stricta*) which grows wild in Minnesota is made into durable "grass" mattings.

Broom corn is the tops of a variety of sorghum (*Andropogon sorghum*) cultivated in the United States for making brooms and whisks.

Rice root, broomroot, zacaton, or Mexican whisk, is the root of a grass (*Epicampes macroura*) which grows in the highlands of Mexico. It is an important brush fiber.

**Wood as fiber.** Willow, the basket willow (*Salix* sp.), is grown in many parts of Europe. The young shoots or sprouts are used for making furniture and baskets.

Wood shavings, or chip, are made into hat braids for millinery in Japan and central Europe.

**Rattan.** Rattan comes from the East Indies. It is the stem of climbing palms (*Calamus* sp.). These palms are sometimes many hundred feet in length and usually have strong, hooked spines on the stems and leaves. Rattan owes its value to its strength, its flexibility, and its uniform size. In Asia it is used to an enormous extent for basketry and ropes. It is imported for use in making furniture, baskets, canes, whips, etc. In preparing rattan "cane" for market the natives clean off the leaves and outer cuticle by pulling the stems through a notch in a tree or a board. After this dressing the rattan is cut into lengths and tied in bundles for sale. The smooth "bark" of rattan is split off by machinery in long slender strips and is used in caning chairs. Peeled rattan, or "reed," is used for furniture, basketry, and stiff brushes.

**Bamboo.** Bamboo (*Bambusa* sp.) is the largest plant of the grass family. It is found in tropical countries, but is most common in Japan, China, India, and the East Indies. Its stem sometimes reaches a foot in diameter, and its height is occasionally a hundred feet. In its native countries it is used for housebuilding and for all sorts of construction, for making furniture, agricultural implements, canes, fishing-rods, and innumerable other things. In China bamboo is used in making paper. The soft, tender shoots just appearing aboveground are sometimes cooked and eaten in both Japan and China.

Bamboo splits readily into long flexible strips which are woven into basketry of all kinds and are also used for making stiff brushes.

**Seaweed fibers.** Marine fiber is prepared from a seaweed (*Posidonia australis*) dredged up from shallow bays along the coast of South Australia. It has a limited use for upholstery and heat insulation. It has been spun with wool.

After seaweeds are dried and cleaned they are considerably used in many parts of the world for upholstery and

mattresses. They are also employed for fertilizer, for food, and in making iodine.

**Spanish moss.** Spanish moss (Florida moss or long moss) grows from South Carolina to Argentina, hanging in dense masses from the branches of trees. The outer cuticle is removed from the plant (*Tillandsia usneoides*) by machinery, and the remaining fiber, which resembles horsehair, is used for upholstery. The unprepared moss is used as a material for packing fruit and glass.

**Sphagnum.** Sphagnum moss grows in swamps and peat bogs in many countries. When dried it makes excellent packing for bulbs and for the roots of live plants. By special processes it has been prepared for surgical dressings. (See peat fiber, under Coal.)

**Pine-needle wool.** Pine-needle wool has been made from the leaves of the longleaf pine of the United States and from the European pine also. It is suitable for upholstery and for making mattings.

**Luffa.** Luffas, or vegetable sponges, are the cleaned fibrous parts of the ripe fruit of the dishrag vine (*Luffa* sp.), which belongs to the gourd family. They are exported from Japan.

**Oakum.** Oakum is prepared from the short waste fibers of tow and old cordage. It is treated with oils and tar and used chiefly for calking the seams in ships.

**Paper.** Paper is made from almost any fairly cheap fibrous material. Spruce wood is the raw material most largely used, poplar furnishing about one eighth of the total in the United States. The wood is cut in small pieces and is ground or otherwise reduced to fine fragments which when mixed with water form a pulp. By chemical treatment it is thoroughly washed and cleaned from all the gummy and other elements of the wood, leaving a fairly pure cellulose fiber. The pulp is fed automatically on a moving belt made of wire cloth and usually has added to it "sizing" in the form of hard resin. The soft sheet of pulp is pressed between felt rolls, is dried, and is then passed

through a series of heated metal rollers which compact the fibers and give the paper a smooth, hard surface. Many papers and cardboards are "filled," or "loaded"; that is, they have kaolin, talc, or some other powdered mineral substance added to the pulp to make them heavier and denser. Blotting-paper has no sizing added to it and is not "calendered" by the heavy rollers.

Cotton rags are very important for paper stock; linen rags make the best paper; jute butts, old burlap, waste ropes, and refuse from various mills go into cheaper papers. Straw is a cheap stock for low-grade papers and strawboard. Very fine paper is made by hand in Japan from the inner bark of the paper-mulberry tree and other similar materials. The enormous need for paper stimulates a constant search for raw materials. Efforts have been made to utilize the waste straw from the rice fields of Louisiana, the flax straw of the Northwest, the cotton stalks of the South, the refuse (bagasse) from crushed sugar cane, the fibrous part of corn stalks, and many other things which have potential value.

Esparto grass, alfa or halfa (*Stipa tenacissima*), is a hard, wiry grass which grows wild in Algeria, Tunisia, and Spain. It is an especially good paper stock and much is exported.

The largest quantities of paper are produced in the United States, Canada, England, Germany, France, and Scandinavia. New York, Wisconsin, Massachusetts, Maine, and Pennsylvania are the chief paper-making states.

Aside from the very common uses of paper for printing, wrapping, writing, etc., it is employed for a constantly increasing variety of purposes. Glazed papers are prepared with casein, paraffin, carnauba wax, etc.; roofing-papers are treated with tar and asphalt; building-papers are stiffened and sometimes fireproofed by the use of resins, oils, and chemicals; imitations of leather are made by coating paper with drying oils and other substances; papers are used increasingly for towels, napkins, surgical dressings or bandages, and for cleaning. Wood pulp mixed with cementing substances is molded under pres-

sure into papier-mâché and makes articles of surprising strength and durability. It has been used sometimes for car wheels. Paper cord and twine are more or less used for tying small parcels, and paper yarn is woven into very satisfactory floor coverings.

An important use for cotton rags has developed within recent years in the preparation of a material known as vulcanized fiber, or diamond fiber, and by various other trade names. Clean cotton rags are worked into a pulp which is made into sheets more or less resembling blotting-paper. This is treated in an acid bath. Strong acids completely destroy cotton, but the acid used in this process does no more than soften it and render the fiber more or less jelly-like for the time being. The sheets are dried, rolled, and worked, and as a result there is a substance which is strong, tough, and hard, partaking of some of the qualities of hard rubber and of leather. It is used for hand bags and many other purposes for which leather is employed, and is cut or molded into a variety of shapes and used for insulation, tubing, washers, gear wheels, etc.

**Celluloid.** Although not a fibrous material, celluloid is made, like paper, from a base of cellulose. The material, which must be very pure, is acted on by a mixture of nitric and sulphuric acids, which converts it into nitrocellulose. This is thoroughly mixed with melted camphor by being ground in heated rollers. It dissolves in the camphor, forming a tough, plastic mass which is then molded by pressure into any desired form. It is then planed in sheets from solid blocks in a machine similar to a veneering-machine. Celluloid is made in many colors and is used as a substitute for hard rubber, tortoise shell, and ivory; for knife handles, brushes, combs, and other toilet and fancy articles; for billiard balls, piano keys, collars and cuffs, and articles of jewelry in imitation of coral and jet. Preparations commonly called lacquers, taking the place of varnishes, are often liquid forms of this same material.

Similar materials are sold under such trade names as pyralin, xylonite, etc.

**Silk.** Silk is obtained by unwinding or reeling the cocoons of the cultivated silkworm (*Bombyx mori*). This insect is raised with great care in countries where there is cheap labor. The largest production is in Japan, with China second. Italy produces much silk, and other Mediterranean countries lesser amounts. A fairly large amount is raised also in the Balkans and eastward through Turkey, Syria, and Persia. The United States is the leading manufacturer of silks, followed by France and other European countries.

The eggs of the cultivated silkworm are a trifle larger than the head of a pin. Minute worms hatch from the eggs and are fed on fresh chopped mulberry leaves. They grow larger, shed their skins, resume feeding, and again grow larger and shed their skins. They molt thus three or four times in a period of from three weeks to a month, by which time they are fat white worms three and a half inches in length. They are next placed on straw or bamboo racks, where they spin cocoons white or yellow in color and an inch or a trifle more in length. Under natural conditions a white moth will emerge from each cocoon in perhaps two weeks, and the females will lay eggs for the next crop of worms. The work of producing silk cocoons is a house industry carried on chiefly by farmers' wives and children and requiring much care. The worms must be kept at an even temperature free from drafts, the trays on which they are fed must be kept clean, and large quantities of fresh mulberry leaves must be given them very frequently. Soon after the cocoons are finished, they must be "choked," or killed, to prevent the insect from emerging and breaking the fiber, thus making reeling impossible. Many farmers sell their cocoons to dealers, who send them to factories (filatures) where the cocoons are promptly baked in great ovens. Otherwise they must be killed by steam or dry heat at home. A limited number of cocoons are not killed, in order that there may be moths to lay eggs for the next crop; but the best plan is usually for the farmer to purchase eggs guaranteed free from disease from

dealers who make a specialty of raising stock. In Japan three crops of cocoons are usually produced in a year.

For reeling, the cocoons are placed in basins of hot water. This softens a natural gum (sericin) which covers the fibers and holds the cocoons together. The outer fibers (first threads or frisons) are brushed off; then the operator, taking the end of a filament from a cocoon, joins it to five or six others and passes them all together through a glass button and thence to a reel. The several filaments adhere to each other and are joined closely by twisting and rubbing in the reeling-machinery. The finest strand of raw silk usually contains filaments from at least five cocoons. Operators who are not skillful in reeling may need to use ten or more cocoons at a time to get a strand which they can handle. The work of reeling is a factory industry in Italy, in France, to a large extent in Japan, and in a few places in China. There is still a large amount of silk reeled by hand in the homes of peasants in China, Japan, India, Turkey, and Syria.

According to figures vouched for by the Silk Association of Japan, 2400 healthy silkworm eggs should in the end produce about 2000 full-grown worms, which during their growth would need about 125 pounds of mulberry leaves. The grower should then expect to get 1800 cocoons, which, when reeled, would yield one and a quarter pounds of raw silk.

Thrown silk is commonly made by twisting two or more strands of raw silk together (doubling). It corresponds with what in cotton or wool would be called yarn. For the warp of most fabrics the threads are strongly twisted, and this kind of thrown silk is called organzine. The filling, or weft, is commonly loosely twisted and is known as tram. Floss silk and embroidery silk are loosely twisted. Sewing-silk, on the other hand, is twisted hard, is doubled, and is then twisted again in a reverse direction.

Silk fabrics, as well as raw silk, are handled by wholesale dealers at prices dependent in part on the weight. In dyeing or finishing silks it is a very common practice to add gums,

FIG. 26. Gathering Cocoons in Japan

Silkworms were placed on racks of straw, where they spun their cocoons. The cocoons will be baked in ovens, to kill the dormant insects, and then they will go to steam filatures, where the raw silk will be reeled from them

salts of tin, and other substances which adhere closely to the fiber but are practically invisible. These add greatly to the weight and make the buyer think the fabric is a heavy silk.

Waste silk is the unreelable first threads, or frisons, from the outsides of the cocoons and the reel tailings left from the inner parts of cocoons that have been reeled.

Spun silk is manufactured from waste silk and pierced cocoons. The pierced cocoons are first boiled in soapsuds to remove the natural gum and are then dried. Next they are pulled to pieces and thoroughly loosened by machinery, and the fibers are combed and cleaned. Following this, the silk is run through machines which treat it almost exactly as cotton and wool are treated and so transform it into a spun yarn. Schappe silk is the name applied in Europe to spun silk. It is often thought that there is some essential difference between the two, owing possibly to the fact that in Europe the gum is generally loosened by fermenting rather than by washing in hot soapsuds. Some persons restrict the term "schappe" to fabrics woven with spun silk.

Silk gut is made chiefly in Murcia, Spain, and in Japan, although some is produced in Italy and China. The full-grown worm has in its body a large sac full of a very sticky substance which becomes silk as the insect spins it. To make gut the worms are soaked in vinegar; after proper preparation they are quickly pulled apart. In the hands of a skillful worker the gummy material stretches out, forming an even strand three feet in length, which is carefully dried. Gut is used chiefly for leaders for fishing-lines.

Wild silks of various kinds are produced by a number of other insects. The most important is tussah (tasar, tusser), a brown silk produced by an insect (*Antheræa pernyi*) which feeds on oak leaves and is raised out of doors. The province of Shantung, China, is the chief producing locality. A similar insect (*A. mylitta*) produces silk in India. A wild silk of Japan known as yamamai is from still another species (*A. yamamai*).

Many experiments have been made with the cocoons and webs of other insects. Spider web has been repeatedly spun and woven in Europe but has never been a commercial success. In former years the natives of Madagascar made beautiful fabrics of spider silk. Certain species of shellfish (*Pinna*, *Mytilus*) have a silky fibrous byssus. In Sicily it was the fashion many years ago for men to wear waistcoats woven of this material.

**Rayon.** Artificial silk is very popular, largely because of its high luster, which makes it appropriate for articles in which beauty is the first consideration.

It is usually made in the United States from a base of very pure wood pulp, although any pure cellulose, such as cotton, will serve. The most important method of manufacture at the present time is the viscose process. In this process the raw stock, spruce wood, is treated with caustic soda and other chemicals till a thick, viscous solution is obtained. This is formed into threads by being forced out under pressure through the openings of very fine tubes and dried quickly. The threads are at the same time led to reels and wound as rapidly as they are formed. There are many variations on the chemical processes employed and on the mechanical arrangements used for forming and drying the threads. As a rule manufacturers regard the entire process as secret, even in its general details.

Other processes are or have been employed, especially in Europe, the most important being the Chardonnet and the cuprammonium. In the Chardonnet process cotton is treated with nitric acid and is then dissolved in alcohol and ether.

Artificial silk has been made by forming threads of gelatin and giving them chemical treatment to harden them.

**Hair.** Hair, the natural covering of many animals, is, strictly speaking, quite different from fur or wool. Many animals have both hair and fur; for example, the mink, the sable, and the fur seal. In all such cases the hair is longer, coarser, and deeper rooted than the fur and usually hides it. For this reason it is often referred to as "overhair." The overhairs are removed in

order to display the beauty of seal, otter, beaver, and various other furs. Most animals produce no fur but are covered with hair. The sheep's covering of wool is not hair, although the poorest breeds of sheep produce more or less hair with their wool. Under a microscope hair appears as a rather coarse cylinder with a fairly smooth surface. Wool and fur are generally smaller in diameter and covered with a great number of very minute scales. The microscopic appearance of the scales is so characteristic that it is possible by studying them to tell the breed of sheep which produced a sample of wool or the name of the animal on which a certain fur grew.

**Human hair.** Human hair comes on the market chiefly from China, Austria, Italy, and Germany. The supply actually amounts to many tons annually. It is employed principally for wigs, switches, and similar articles, and for making hair nets. Immense quantities of Chinese queues have been employed to make a strong fabric used as press cloth in vegetable-oil mills.

**Horsehair.** Horsehair, from the manes and tails of horses (*Equus*), comes on the market from Russia, China, Argentina, Germany, and other countries. It is used for weaving in haircloth and for making brushes, sieves, and bows for musical instruments. When curled, it is used for stuffing mattresses and furniture. The short hair is used for cheap felt. Some hair of this kind is obtained by clipping horses, but most of it comes from the tanneries. The poorest is mixed in plaster.

**Cow hair.** The long hair from the tails of cows (*Bos taurus*) is used like horsehair. The short hair which covers the rest of the body is used for mixing in plaster, for making roofing-felt, and for insulating against heat and sound. The best of it goes into coarse yarns. Paintbrushes are sometimes made of "Siberian ox hair," said to be from the inside of cows' ears. This hair does not necessarily come from Siberia.

**Camel hair.** Camel hair comes on the market chiefly from Turkestan, China, and northwest India. At certain times in

the year the animal (*Camelus bactrianus*) sheds its hair, which can easily be plucked by hand. It comes chiefly in brown and white. There are two kinds of camel hair: the long coarse outer "beard hair" and the shorter soft under hair (like wool or fur). The beard hair is used in Europe and America for making a remarkably strong fabric for press cloth in cotton-oil mills and other oil mills. The under hair is woven into soft dress goods, underwear, shawls, and blankets. Certain qualities are used for artist's brushes, although most so-called camel's-hair brushes are made of squirrel or kolinsky tails.

**Bristles.** Bristles are obtained chiefly from Russia and China. In these countries the pig (*Sus*) is much like its ancestor the wild boar and has not been improved by breeding. The bristles of these animals are much more valuable than those of the improved breeds raised in America, and are used for making brushes for many purposes. The hair from pigs killed in slaughterhouses, like that from cow and horse skins, is used for plaster etc.

**Goat hair.** Goat hair and kid hair of commerce are from the common goat (*Capra hircus*). It is obtained in Turkey, Russia, Asia Minor, and India. It is usually from three to four and a half inches long and is white, red, or black in color. It is used in making coarse blankets and carpets. The poorest qualities go into plaster.

**Angora, mohair.** Angora, or mohair, comes from the Angora goat and is produced in South Africa, Turkey, and the United States. It is a very glossy fiber, sometimes fifteen inches in length, and is used in making dress goods, braids, plushes, and imitation furs.

**Cashmere.** Cashmere wool is produced in Tibet and the highlands of central Asia by the Cashmere goat. This animal has fine soft wool and longer, coarser hair. The wool is used in making true Cashmere shawls, which are very highly valued on account of their beauty and durability. Most goods commonly sold as cashmere are made of sheep's wool.

**Alpaca.** Alpaca wool is obtained in Peru and Bolivia, from an animal (*Auchenia pacos*) of the camel tribe. This wool is fine, strong, and particularly long. It is used for making dress goods. The llama (*A. lama*) and the vicuña (*A. vicugna*) are similar animals, the skins and hair of which are used in Peru for robes. Vicuña wool is remarkably soft and fine and some is exported, but most of the so-called vicuña fabrics on the American market are made of sheep's wool. Llamas are used in Peru as beasts of burden.

**Hair for brushes.** The hair of squirrel (*Sciurus*) tails is used in making artist's brushes. (The output of gray squirrel tails from Siberia in a recent year was twenty-one tons.) Brushes are also made of the hair of the sable, the fitch, the badger, and the bear.

**Wool.** There are many breeds of sheep (*Ovis*) producing wools which differ in length and fineness. The very finest but also the shortest is the merino. This variety of sheep originated in Spain, but was carried to Saxony (Electoral), Silesia, Hungary, France (Rambouillet), and later into Australia, the United States, South Africa, and Argentina. In some places it has remained fairly pure, but very generally it has been crossed with other breeds. This has resulted, of course, in a change in the character of the wool. In the British Isles shepherds have bred sheep carefully for hundreds of years, chiefly with the object of producing mutton. Of the British "longwools" thus developed, the most important breeds are the Lincoln, the Cotswold, the Leicester, and the Romney. Like the Scotch Cheviot, these are coarse wools when of pure breed, but are usually quite glossy, being known in the trade as luster or semi-luster wools. The Down wools—Southdown, Hampshire, Oxford, and Shropshire—are shorter, softer, and finer. Sheep raisers in Argentina, South Africa, New Zealand, and Australia have commonly bred a mixture of merino with British breeds. The result is a strain of sheep which give excellent mutton and at the same time produce large fleeces of very good wool. These

wools are known as crossbreds. In Argentina the most popular is a cross of merino and Lincoln. As a rule Australia and New Zealand use such breeds as the Leicester, the Romney, and the Corriedale, rather than the Lincoln, for crossing with the merino. Shepherds in Asia and Africa never selected individual sheep for breeding, as was done in Europe, and the wools are all coarse and rough. In the trade these are called native wools, and their chief use is for making carpets. In Syria and eastward one peculiar type, the fat-tailed sheep, has developed, the tail sometimes amounting to one third the total weight of the animal. In tropical Brazil there are sheep which, owing largely to the climate, produce almost no wool and are covered with a rather scanty growth of hair. These animals are of value only for food and for their skins (cabretta).

When sheep are sheared, the wool holds together almost like a loose skin. Wools come to market tied in bundles, each of which is a fleece; that is to say, the wool from one sheep. But since not all the sheep in a flock produce wool of the same identical quality, the fleeces are graded at the wholesale warehouses according to the fineness and the length of the wool which seems to be predominant. On arrival at a factory the fleeces are cut open and spread out, one by one, on a table for sorting. The wool on any sheep is finest on the shoulder, is almost as good on the sides, and is shortest and poorest on the head and the legs. The wool sorter will "skirt" the open fleece by throwing aside the poor qualities from the edges of the fleece, and he may separate the good wool into two or more grades according to his judgment of the wool which is before him and the needs of the mill.

For the purposes of spinning and weaving, wool has certain qualities which influence its use and value. Among these are fineness, length, strength, softness, pliability, elasticity, luster, and color. These qualities are more or less dependent on the breed of sheep, and wool dealers and manufacturers class wools as merino, British, crossbred, and carpet wools. The fineness

and the length (or staple) determine what kind of yarn a wool will spin. With regard to fineness pure merino is considered the standard, and all wools are graded on a theoretical comparison with merino of more or less pure breed. Merino wool is peculiar in showing regular "crimps" all along the fiber,

FIG. 27. Combing Wool in Philadelphia, Pennsylvania

A part of the process of making worsted yarn. The entire tablelike circular mechanism, with the great spools of wool, revolves around the center. The wool is drawn in by the big spurred wheels, passes through combs with many sharp-pointed metal teeth, and is formed into a loose, soft, ropelike sliver which drops into the tall cardboard cans at the right

the finest wool always having the most crimps, sometimes as many as twenty in the length of an inch. By examining the crimps closely a man can judge the diameter of the fiber and so estimate the proportion of merino blood. Coarse wools are somewhat wavy, and hair is straight. The ordinary commercial grades are (1) full blood (XX), a wool which will spin No. 60 yarn; (2) three-quarter blood (X), to spin No. 50;

(3) half blood, to spin No. 40; (4) three-eighths blood, to spin No. 36; (5) quarter blood, to spin No. 32; (6) low quarter blood, to spin No. 20; (7) common and braid, to spin No. 16. These commercial names really mean that a sample of wool graded as half blood is of the same fineness as a wool from a half-blood merino sheep, although the sample may be from a sheep with no merino blood at all.

In general the short fine wools (two inches or less in length) are carded and spun into woolen yarns and the long wools are combed and spun into worsted yarns. It used to be easy to classify wools on this basis (carding or combing), but improvements in machinery now make it possible to comb wools which were too short for that use a few years ago.

Lamb's wool is shorn from animals up to seven months old. Hoggets, or hogs, is the first shearing from sheep about one year old; it is relatively long and fine, being classed as a slightly superior quality.

Pulled wool (skin wool, tanner's wool) is from the skins of sheep that have been killed for food. In America such skins are treated on the flesh side with chemicals, but in Europe and Asia they are "sweated" to loosen the roots of the wool. Some authorities state that half the total amount of wool used annually in the world is from sheep which have been slaughtered. This wool is said to be inferior to first-class clipped wool and is not supposed to be used in fabrics of the very finest qualities.

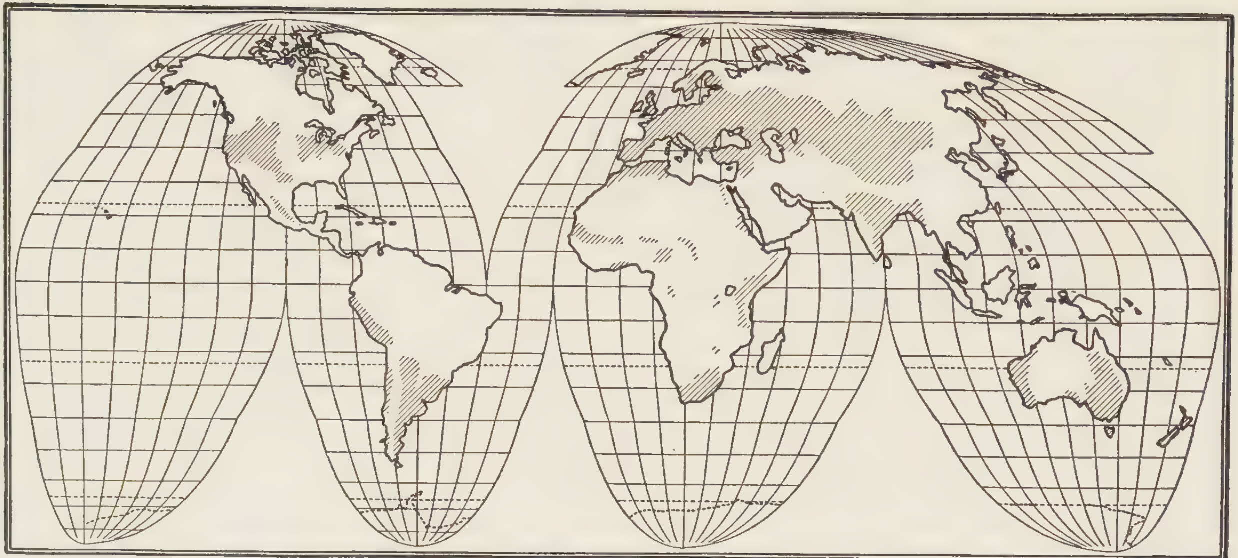
In actual amount of wool produced in the world Australia leads, with wools of high class. Russia was formerly second on the list, with much poorer wools, but now both Argentina and the United States surpass it. New Zealand, South Africa, the United Kingdom, and Uruguay are all large producers, although the complete list covers practically all temperate parts of the globe. There are large wool-pulling establishments near the slaughterhouses in the United States. In Europe the chief wool-pulling center is Mazamet, France.

As the wool grows on a healthy sheep, nature keeps it thoroughly protected by natural grease, which causes it to shed water and prevents it from becoming hopelessly tangled or matted. Of course dirt readily sticks to the grease, and on some dusty ranges in the western part of the United States the weight of a fleece may be represented by fully 75 per cent of dirt and grease. Even wool which is fairly free from dirt will often lose fully half its weight when the grease is removed by scouring. The usual process is to wash out the grease with warm water and soap, but some large mills employ a chemical process by which they save the grease (wool fat, suint, yolk, degras).

Raw wool contains some potash derived from perspiration, which can also be recovered. When sheep are pastured where there are plants with burs and hooked seeds, these catch in the wool and are very difficult to remove. If there are many fragments of seeds, twigs, straw, etc. in the wool, they must be carbonized by treatment with sulphuric acid.

In all the processes of making wool into yarn and cloth there are short, broken, or tangled fibers which do not pass through the machines. These are termed "waste." The best grades of waste are mixed with good wool in yarns or else are spun with "shoddy."

Shoddy is made by tearing up old woolen goods, rags, or cloth cuttings in a machine until the fabric and the yarn of which it was made are reduced to a mass of loose fibers. It is mixed with wool in the manufacture of cheap yarns and fabrics. Shoddy made of new fabrics of good quality is composed of fibers that are relatively long, sometimes as much as three fourths of an inch. Most shoddy is shorter than this, and some of it is not even pure wool, being made from mixed fabrics. Good shoddy is really wool, it is cheaper than new longer-staple wool, and the world needs it, for millions of people must have warm clothing. It would be an economic crime not to manufacture and sell fabrics made in whole or in part of shoddy. It is true, of course, that shoddy will not



Goode's Homolosine Projection

Fig. 28. Areas of Wool Production

Wool is produced in great quantities in the semiarid regions of the world, for it is there that sheep thrive best

wear as well as first-class new wool, and therefore the buyer of wool yarns or fabrics should be truthfully informed as to what he is purchasing.

Mungo is made from hard yarns and fabrics and is generally softer and finer than shoddy. Flocks is very short and comes mostly from finishers of cloth. It is used in filling cheap yarns and for surfacing certain wall papers.

Woolen fabrics are often adulterated with cotton, and there are many mixed goods woven with warp threads of cotton or silk and weft of wool, or vice versa. Carpets frequently have a warp or a backing made of jute, hemp, linen, or cotton.

**Felt.** Felt is not made by spinning or weaving, but the fibers are simply tangled and pressed together. They are covered with very minute scales, invisible except under a powerful microscope. Because of the scales the surface of the fibers is rough, and when they are tangled and pressed, the scales interlock and hold each other. The better qualities of felt are made of wool from sheep and lambs and of fur from many animals.

The nutria, or coypu (*Myopotamus coypus*), furnishes a large percentage of the fur used in making hats. The animal inhabits river banks in Argentina and Uruguay. Rabbit fur (*Lepus*), mostly from Australia and New Zealand, is used in very large quantities for felt hats. Coney and hare are used in the same way, as are also clippings of beaver, muskrat, otter, and other furs.

The lowest grades of felt are made from the short hair of cattle and horses and from the poorest qualities of goat and other hair. These felts hold together chiefly because the fibers are tangled and matted together. They are naturally looser in texture than are felts made of fine fur, the fibers of which are covered with scales that cling to each other. These felts are used for insulating against heat and sound in refrigerators and buildings, and in shoes, washers, cartridges, polishing-pads, etc.

**Whalebone.** Whalebone is obtained from the mouth of the whale (*Balœna mysticetus*). It is not bone, but is a substance

similar in its nature to hair. Certain species of whales have in the upper jaw a series of long plates hanging from the roof of the mouth, with bristly fringes on each side of the tongue. These fringed plates are the whalebone, or baleen. Whalebone is used for stiffening in corsets, for whips and canes, and for making brushes. When split fine it has sometimes been woven into silk goods to stiffen them and make them rustle.

**Asbestos.** Asbestos, or asbestus, is a natural mineral fiber. The asbestos usually found on the market is a fibrous variety of serpentine called chrysotile (hydrous magnesium silicate). A fibrous variety of amphibole is also known as asbestos, the best being the Italian, which sometimes has a fiber twelve inches or more in length. The most important asbestos mines are in the province of Quebec, Canada, but asbestos is also mined in Southern Rhodesia and the Union of South Africa and in Cyprus, Russia, and other countries. In the United States it is mined in Arizona, Idaho, and other states.

Short-fiber asbestos is used in making fireproof millboard, paper, shingles, flooring, and electric insulators and for mixing in plaster and paint, stove cement, pipe-covering, etc. Long-fiber asbestos, besides being used in these ways, is spun into yarn and woven into fire-resisting fabric for theater curtains, firemen's clothing, gloves, mats, iron holders, etc., and is also used in filters and for gas grates.

**Mineral wool.** Mineral wool, sometimes called rock wool, silicate cotton, or asbestos, is an artificial substance produced by melting slag and limestone and converting the molten mixture to a very fine fibrous state by means of a steam blast. It is used for much the same purposes as true asbestos, but cannot be spun into thread. It is extensively employed in walls and floors as a fireproof packing material for deadening sound, and as a nonconducting packing round boilers and steam pipes and in refrigerators.

**Wires.** Wires are made of almost all kinds of metal, and their uses are so varied that it is hopeless to try to itemize them.

Among those which take the greatest quantity of wire are cables, electric conductors, fencing, and netting. Wire cables are spun by much the same kind of machinery as is used in forming rope and twine. Wire netting is actually a woven fabric.

**Tinsel.** Tinsel consists of narrow strips of very thin metal. It is often woven with silk, wool, or cotton to make especially showy fabrics.

**Steel wool.** Steel wool is simply shavings of steel and is an important abrasive. It can be regarded as a fibrous material.

## FEATHERS

**Ostrich feathers.** Ostrich feathers are chiefly from domesticated birds (*Struthio*) in South Africa, although there is still a considerable output of feathers from wild ostriches killed in central Africa. There are ostrich farms in Egypt and Argentina and in this country in California. The feathers are carefully cut from the birds on the farms, and soon grow again. The best plumes are from the wings and tails of male birds. They are quoted under such names as "superprimes," "prime whites," "blacks," "grays," "shorts," "feminas," "byocks," "spadonas," and "floss," and are sold by the pound in the wholesale market of Port Elizabeth.

The ema (*Rhea*), or South American ostrich, is a wild bird found over a wide area in Brazil, Argentina, and Bolivia. Its feathers are much used in feather dusters.

Feathers and bird skins for millinery, boas, muffs, and dress trimming are obtained from both wild and domesticated birds in many countries. The feathers of the cock, duck, turkey, pheasant, heron, grebe, bird of paradise, humming bird, marabou, and others are important.

Feathers for beds, pillows, and upholstery are from the domestic goose, duck, swan, and hen. Down is from the goose, and a fine quality is taken from the nests of the eider duck. Feathers are also used in making flies for fishing.

Quills of turkey and other feathers are made into toothpicks, brushes, and an article called featherbone, used by makers of clothing.

## FURS

The skins of animals with the hair (or fur) are tanned or dressed for clothing and rugs. Most of the valuable furs of commerce come from the cold countries of the Northern Hemisphere. London, St. Louis, Nizhni Novgorod, and Leipzig are the chief fur markets. The past importance of Leipzig has been due in large part to the skill of its workers in dressing skins and dyeing furs.

Siberia supplies sable (*Martes zibellina*), marten and kolinsky (*Mustela*), mink (*Putorius*), ermine (*P. erminea*), fitch, or polecat (*P. fœtidus*), marmot (*Arctomys bobac*), squirrel (*Sciurus*), hare (*Lepus*), otter (*Lutra*), badger (*Meles taxus*), bear (*Ursus*), silver, blue, cross, red, and Arctic (or white) fox (*Vulpes*), lynx (*Felis lynx*), and other skins.

British America furnishes beaver (*Castor canadensis*), otter (*Lutra canadensis*), muskrat, or musquash (*Fiber zibethicus*), mink (*Putorius vison*), weasel (*P. vulgaris*), ermine (*P. erminea*), brown marten, commonly called Hudson Bay sable or American sable (*Mustela*), stone marten, baum marten, fisher (*M. pennanti*), groundhog, marmot, or woodchuck (*Arctomys monax*), skunk (*Mephitis americana*), badger (*Meles labradoriana*), wolverine (*Gulo luscus*), black, brown, grizzly, and polar bear (*Ursus*), opossum (*Didelphys virginiana*), raccoon (*Procyon lotor*), silver, black, gray, white, blue, cross, red, and kitt fox (*Vulpes*), cougar (*Felis cougar*), lynx (*F. lynx*), wildcat (*F. catus*), house cat (*F. domestica*), wolf, and coyote (*Canis lutrans*).

Even within the limits of the United States there is a very large production of furs, the following being important: muskrat (*Fiber zibethicus*), opossum (*Didelphys virginiana*), raccoon (*Procyon lotor*), mole (*Talpa*), skunk (*Mephitis americana*), fox (*Vulpes*), etc., with smaller quantities of beaver

(*Castor canadensis*), otter (*Lutra canadensis*), mink (*Putorius*), badger (*Meles labradoriana*), bear (*Ursus*), and many others.

The true fur seal (*Otaria ursina*) is found in the North Pacific, particularly at the Pribilof Islands off the Alaska coast, and in the South Atlantic (*Otaria nigrescens*), especially at Lobos Island in Uruguay. Sea otter (*Enhydris marina*) is one of the most costly furs.

Argentina and the Andes are the source of Patagonian fox, or zorrino, weasel, chinchilla (*Chinchilla lanigera*), guanaco (*Auchenia huanaco*), and otter (*Lutra*). Nutria (*Myopotamus coypus*) is mostly from the Rio de la Plata or its tributaries.

Australia supplies wallaby, or Australian squirrel (*Macropus thetidis*), opossum (*Phalangista*), ringtail opossum, wombat, kangaroo (*Macropus*), and "red Australian fox."

Animals of the cat family, mostly those of Asia and Africa, supply some furs. The chief are leopard (*Felis pardus*), panther (*F. panthera*), caracal, wildcat (*F. catus*), jaguar (*F. onca*), tiger (*F. tigris*), lion (*F. leo*), and lynx (*F. lynx*). Skins of the domestic cat (*F. domestica*) are used in great numbers, often being made to imitate other furs.

The tropics do not as a rule produce the best furs, for, naturally, animals do not require heavy coats in hot countries; nevertheless there is some production of monkey and other furs as well as those from the cat tribe.

Sheepskins (*Ovis*) are much used in Turkey and Persia, but seldom in Europe and America except for coat linings. Lambskins of various different breeds owe their beauty to the waviness, or curl, of the wool. The chief types are Tibet lamb, astrakhan, krimmer, pinhead, caracul (or karacul), Persian lamb, and broadtail. The two latter are from unborn or prematurely born (slink) lambs.

Goatskins (*Capra hircus*) are used for rugs, and some kidskins are used as furs. These come chiefly from Russia and Asia. Angora skins are the finest quality of goat. They are used chiefly for rugs and for children's furs.

Among the other fur skins usually on the market are greater or less numbers of dog (*Canis*), jackal, chamois (*Rupricapra*), moufflon (*Ovis musimon*), deer (*Cervus*), calf (*Bos*), colt, and pony (*Equus*).

Foxes, mink, and several other fur-bearing animals are raised in more or less captivity in Canada, British America, and Alaska. Silver-fox skins are among the most valuable products of such "farms."

Rabbits or hares (*Lepus* sp.) are raised in Belgium, France, and Germany, and in much smaller numbers in this country in California and Texas. The largest production of rabbit skins is from wild rabbits of Australia and New Zealand, but their skins are of lower grade, being valued chiefly for making felt hats.

Skins of the grebe (*Podicepes*) and of a few other birds are classed commercially among the furs.

The commercial names of furs are often far from accurate in indicating the animal on which the fur grew. Cheap furs like cat, rabbit, muskrat, and nutria are dyed, clipped, and treated to make them resemble more costly skins. When marketed they go under such names as Hudson seal, electric seal, etc.

Some costly furs owe their beauty to long overhairs of contrasting color. These are imitated by fastening white hairs in cheap dark furs. The result gives "pointed" fox and similar furs, which are of course inferior to the furs they imitate.

Woven fabrics similar to plush are made to resemble fur.

# SKINS, HIDES, AND LEATHERS

The skins of animals with the hair removed are prepared by several processes, known as tanning, dressing, tawing, currying, etc. The kind and the quality of leather depend to some extent, of course, on the animal from which the skin came, but they are very largely dependent on the treatment which the skin receives.

In a tannery the dry hides are first soaked in vats of water to remove the salt and make them sufficiently soft and flexible for further treatment. Next they are placed in vats containing limewater, where they remain for perhaps a week. The limewater opens the pores and loosens the hair, which is then removed by scraping. This is done either by hand or by machinery. Then the lime is neutralized, the flesh side of the hide is scraped, and it is ready for actual tanning.

In tanning sole leather the hide is soaked for several days in vats, first in a weak solution and then in a stronger liquor, made by steeping oak bark or hemlock bark in water or by dissolving prepared tanning extracts. This causes a chemical change in the fiber of the hide, rendering it proof against the ordinary process of decay, to which the untanned skin is liable, and making it pliable instead of hard and stiff, as hides are when simply dried without tanning. The tan liquor is made stronger from time to time, and the hides are frequently "handled," or moved about, so that they will come in contact with fresh liquor. After five or six months, sometimes after a year or more, the hide has absorbed all the tannin which it will take up, and the tanning is complete. The hides are then removed from the "pits" and are washed, oiled, dried, dampened, and rolled by brass rollers, which give the leather a gloss on the hair side.

A Shoe

- Upper Leather
  - Goatskin from Asia Minor
  - The people who raise the goats and who ship the skins
  - Chrome for tanning; mining chrome ore
  - Chemical manufacture of bichromate
  - Dyes for coloring and oils and waxes for finishing the leather
- Sole Leather
  - Cattle Hides
    - Cowboys and all their needs
    - Horses, harness, and food
    - Slaughterhouse-killing, skinning
    - Salt-mining, evaporation
    - Wire for fences — manufacture
    - Transportation
  - The Tannery
    - Tanbarks and extracts: hemlock, Pennsylvania; mangrove, East Africa; quebracho, Argentina
    - Oils and glucose for stuffing and finishing
    - Machinery and its production
    - Metals of which it is made
    - Lumber and concrete for the building
- Cotton fabrics for linings
- Linen thread
- Beeswax and paraffin for waxing thread
- Silk thread
- Metal eyelets and hooks
- Wooden pegs, steel pegs
- Rubber buttons, silk laces
- The Factory
  - Building
  - Machinery
  - Workers
  - Office force
  - Selling force
  - Advertising

Much the same result can be accomplished by using "chrome" (chromic acid or bichromate of potash) instead of vegetable tans, and the process takes only a month. There is still a lack of agreement among both tanners and users as to the merits of chrome-tanned sole leather. Different qualities of leathers are produced by the use of various vegetable tanning materials on different kinds of skins.

Typical market quotations on sole leather are on such qualities as oak-tanned, hemlock nonacid, union (a mixture of oak and hemlock barks), and chrome.

After tanning, the hides, or skins, are usually "stuffed" with tallow, stearin, or oils, such as olive, castor, cod-liver, whale, or sperm. These keep the leather flexible, prevent brittleness, and protect against moisture. Glucose and various other substances are used to fill the pores of the leather and, incidentally, to add weight. The work of finishing many leathers involves ironing with heavy, hot rollers so as to give the proper gloss. Patent and enameled leathers are coated with black varnish.

The hide, or skin, of any animal is thick over some parts of the body and thin over other parts. Users of leather want hides of a uniform thickness. It is a very common practice to split a hide by machinery into two or more sheets and to tan or dress the sheets separately. The sheet from the outer, hair or grain, side is termed a skiver, and the part from the flesh side is called a flesher. The skiver is the better quality, for it makes leather with a natural grain, or surface. The thick hides of neat cattle are split so as to make leather which will serve for the same purposes as calfskin or other thinner leathers. Sheepskins are often split into several sheets to make very thin leather for bookbinding. Split leathers are very commonly embossed by pressure in metal forms, or with metal rolls so that they show a surface resembling the natural grain of some more costly leather. This treatment is often given as a part of the process of finishing skivers. In this way such leathers as alligator, seal, and walrus are closely imitated.

Tawing is a process used for preparing glove leathers from kid, lamb, sheep, deer, rat, and other skins. It consists in taking the damp skins freed from hair and tumbling them in a drum containing alum and salt. After drying, they are tumbled in another drum with a mixture of oil, flour, and egg yolk.

Chamois and other wash leathers are made of sheepskin by thoroughly impregnating it with fish oil. The excess oil is squeezed out and, under the name of "degras," is used in currying other leathers.

Rawhide is simply the dried and cleaned skin from which the hair has been removed, softened by oils. It is used for ropes and lariats, belts and belt lacings, whips, and faces for mallets.

Cattle hides (*Bos taurus*), from the slaughterhouses of the United States, Europe, Argentina, Uruguay, and Brazil, are the most important raw material for heavy leathers. Added to these, however, is an immense quantity of hides gathered singly or in small lots in almost all quarters of the world. Hides are from beef cattle and horses, but include those from the humped cattle, or zebu (*Bos indicus*), of India and the water buffalo (*Bubalus buffelus*) of China and the Philippines. The heavy hides of oxen, cows, and horses are used in making sole leather. Calfskins are chiefly for boot and shoe uppers and for bookbinding.

In the tanning business the word "hides" means the skins of full-grown cattle. "Kips" are from cattle two years old. Calfskins and veal skins are from younger animals. Hides are classified as cow, steer, etc. and according to quality, thickness, weight, and freedom from cuts or damage (No. 1, No. 2, etc.). They are further named according to their country or locality of origin and to their mode of preparation; for example, dry, brined, dry-salted, or wet-salted.

Horsehide is used for making "cordovan" leather for shoes, saddles, and razor strops. The part of the hide most used for

leather is an oval piece about three feet long taken from the rump. This leather is exceptionally strong and is more nearly waterproof than that from any other land animal. It is finished in tan, black, and other colors.

Under the general term "skins" are included those of practically all other animals.

Goatskins (*Capra hircus*) from South America, western Asia, Spain, and other regions are used in enormous quantities for

FIG. 29. Tannery in Girard, Ohio

In the production of high-class leather the raw material employed plays an important part. Here the skins are being selected and trimmed

making glazed kid and morocco leather. Chevrettes are the skins of young goats. India is an important producer.

Sheepskins, or roans, make leather which is more porous and softer than that from goats. It is worked up in various finishes for shoe uppers, into moroccos for bookbinding, hat bands, shoe linings, and fancy articles. Kidskins and lambskins go into glove leathers. Parchment is made from the skins of sheep and goats, and vellum from the skins of young calves, lambs, or

kids, by a process which consists mainly of scraping and rubbing down with chalk and pumice. Sheepskins are dressed to make chamois leather.

There are sheep in the warm part of Brazil, back of São Salvador (Bahia), Recife (Pernambuco), and Fortaleza (Ceará), that produce little or no wool, but instead a rather sparse crop of hair. These skins are much less porous than common sheepskins and produce a leather intermediate in quality

FIG. 30. Tannery in Philadelphia, Pennsylvania

Goatskins from all parts of the world are converted into soft kid leather, which Philadelphia sends to all parts of the world. This photograph shows the lime pits which loosen the hair, preparatory to chrome tanning

between typical goat and sheep. They are known in the trade as cabretta. The leather is usually tanned with chrome.

Deerskins of many kinds (*Cervus* sp.) come on the market and are used in making buckskin leather, for gloves, mittens, moccasins, etc., but not all commercial buckskin is from the deer.

Pigskins (*Sus*) go into saddles and traveling-bags; dogskins (*Canis*) are chiefly for gloves; certain kinds of kangaroo

(*Macropus* etc.) make shoe uppers which are remarkably soft and durable. The hair seal, the sea lion, and the walrus (*Odobenus*) have skins with beautiful natural grain, or surface; in addition the skins are nonporous and very durable. They are in much demand. The skins of the white whale (*Beluga*) make what is called porpoise leather, and the skins of some other whales are utilized. Shark skins make good leather. Alligator skins make a leather so ornamental and so strong that it is very much imitated. Snake and lizard leathers are used for pocketbooks and fancy articles. For a comparatively short time during the World War ostrich raising did not pay, and many birds were killed for their skins. The leather has a fancy grain and was used for the same purposes as snake skin. The skins of many other animals, among them the rat, the bat, and the monkey, are in more or less constant demand for special fancy leathers.

**Imitation leather.** There are a number of materials sold as imitation leather. Most of them are made of strong cloth, covered with a coating composed of a drying oil (such as linseed oil) mixed with various gums or other solid substances. The exact composition is usually kept secret by the manufacturers. Imitation leathers are used for almost all purposes for which leather is used, except for shoes and gloves.

# WOODS

The forests of North America consist of both softwoods and hardwoods. Canada, Michigan, Minnesota, the Appalachians, and the Pacific slope are rich in coniferous trees and produce pine, spruce, hemlock, cedar, fir, and redwood lumber. White pine comes from the northern forests, and yellow pine from the southern. Cypress is the typical lumber of Louisiana swamps. Among American hardwoods the oak, chestnut, maple, black birch, hickory, gum, and poplar are the most important. The chief lumber-producing states are Washington, Louisiana, Oregon, Mississippi, and Texas.

Northern Europe and northern Asia produce straight-grained softwoods much like those of North America but of slightly different species. Scandinavia, Russia, Manchuria, and Japan have great forest wealth of this character. Among the hardwoods the oak, ash, chestnut, walnut, beech, and linden are important. Beech is planted in extensive forests in central Europe. The most important lumber markets of Europe are seaport cities near the great forests, such as Riga, Danzig, Stockholm, and Odessa. Japan exports considerable lumber, large quantities of Japanese oak being sent to England.

The trees of Australia are of species entirely different from those found in other parts of the world. They produce many valuable woods, some of which are exported to Europe. Many of the woods have been named because they bear a slight resemblance to those of Europe with which people were already familiar, so that there are various so-called cedars, mahoganies, oaks, etc. Trees of the eucalyptus family are numerous. The wood differs greatly in different species, this genus including woods that range from fairly soft and light in weight and color to very hard, heavy, dark reds and browns. The hard

woods are most numerous, and the trees grow to immense size. New Zealand forests are very different from those of Australia, the most important wood, kauri pine, being very like the yellow pine of the United States. Australian and New Zealand woods are sent to Europe in fairly large quantities.

The tropical forests of South America, like those of Central America, Mexico, Africa, and India, contain many kinds of trees. In northern forests we find large areas of land covered with a single variety of tree, but it is rare to find many trees of one kind growing close together in hot countries. This adds to the difficulty and cost of lumbering. Most tropical woods are hard, heavy, and difficult to work in comparison with straight-grained soft woods like pine and spruce. Some tropical woods, such as mahogany, satinwood, and ebony, are prized for their beauty of color and grain; others, like teak, for their durability; and still others, like lignum-vitæ, for their strength and hardness. Some, such as logwood, are important as dyewoods or, like quebracho, for tanning. Palm trees, so abundant in the tropics, can very rarely be cut into boards, and so their wood is of little importance.

The useful woods of the world come from trees which botanists call exogens. These trees form the new wood in layers just beneath the bark. In climates where the winter is cold enough to stop growth, there is one layer, or ring, of wood formed every year. These rings are seen plainly on a cross section (or the end grain) of almost any wood. Trees of the pine family show in each ring a light part, representing the spring growth, and a darker, more compact part which grew in the summer and the early fall. The rings in the wood of many broad-leaved trees have hollow pores in the spring growth and a band of much denser wood formed later in the year.

The "grain" of wood is the result of cutting in one direction or another across these rings of growth. The grain is not prominent in white pine, for the fibers of the wood are parallel and straight, and there is little difference between spring and

summer wood. The grain shows more plainly in yellow pine, with its hard, resinous bands of summer growth. Chestnut wood is valued for its grain, which is prominent because of the many large pores in the spring wood, alternating with bands of summer wood having scarcely any visible pores. The beauty of grain depends entirely on just how these layers, or rings, of wood are cut by the saw and how their lines happen to show on the face of a board.

If a tree has grown evenly we have straight-grained wood. Sometimes the fibers in one ring, or layer, lie in a direction slightly different from those in the next layer, making the wood cross-grained and difficult to work. This is a disadvantage in such woods as are used for plain construction, but it is a great merit in cabinet woods. For instance, a mahogany which has such cross-grained layers shows, after being polished, a beautiful satiny appearance that changes in different lights. Woodworkers refer to this as "figure," and highly figured woods are always in demand at top prices. The world does not produce enough handsome figured mahogany to supply the demand from manufacturers of fine furniture, railway cars, cameras, and the interior decoration of buildings. Nearly all the best figured wood is therefore cut into very thin sheets (veneers) which are glued on to the face of cheaper wood, such as ordinary mahogany, pine, or birch. Veneers are sometimes cut from the circumference of a log which is revolved in a big lathe while a long knife takes off a broad shaving as wide as the length of the knife. Some veneers are sliced off by an apparatus much like a plane; others, by finely adjusted saws.

Occasional trees grow in a twisted or irregular fashion, giving a grain varied by a "curly," or "bird's-eye," figure. Some trees develop excrescences looking like great warts or knotty growths on the side of the trunk. These are called burls and are fairly common on black walnut. The grain of burl is remarkably curled and twisted and shows well in decorative veneers.

Oak wood has strongly developed medullary rays radiating from the center of the tree to the bark. When an oak log is cut in quarters, the saw cut passes through these compact rays in such a way as to show them plainly in broad, irregular patterns. Quartered-oak boards are cut from the log parallel to the quarter-sawed faces and show these figures in a very decorative way, making another type of figured wood. Some of the handsomest figured oak is cut in veneers.

The grain, or figure, of wood is brought out in finishing. It is easy to fill the pores of chestnut or oak with a liquid or paste darker in color than the wood itself, which protects the wood by closing the pores, and at the same time makes them show very plainly, emphasizing the grain and adding to its beauty. It is necessary to fill the grain of porous wood and to cover any wood with something like paint or varnish to protect it from the changing atmosphere, which, with dampness and dryness, would cause it to swell or shrink. Paint hides the grain, but varnish is transparent and is the finish commonly employed on beautiful woods. A drying oil such as boiled linseed oil is sometimes used alone as a finish, and sometimes woods are treated to a coating of wax. Stains are very commonly used to change the color of wood, and often the stain is combined with the filler or the varnish, or both.

The wood in the outer rings forms a layer called the sapwood, which is usually not so firm, hard, and good as the older wood, called heartwood. This difference is particularly noticeable in ebony, where the black heartwood is high-priced and the light-colored sapwood is not valuable.

Freshly sawed boards, termed green lumber, are full of moisture, most of which must be dried out before the wood is fit for use. Green lumber or wood imperfectly seasoned will not hold its shape; it will shrink, warp, check (split), or twist, whereas properly seasoned lumber will usually "stand" well. Cut lumber properly piled in the open air dries out slowly and may be satisfactorily seasoned in a few months. A great

deal of lumber is "kiln-dried" in large rooms heated by steam. This seasoning process may take only a few hours; if carefully carried out it gives excellent results. Railway ties, piling, telegraph poles, and other wood likely to decay are often treated with creosote, which acts as a preservative. For special purposes wood is rendered fireproof by treatment with sulphate of ammonia or other chemicals.

Lumber is quoted in the wholesale trade at a certain price per foot or per M (thousand feet). A foot means, of course, a piece of wood twelve inches square and one inch thick, or its equivalent. Boards are cut in different thicknesses, and quotations are in quarter-inches; thus 4/4 is one inch thick, 6/4 is one and one-half inches thick, and 10/4 is two and one-half inches thick. Some fancy woods are sold by weight more commonly than by measure. Lumber is graded according to its freedom from knots, sapwood, checks (or cracks), stains, etc.

Softwoods, needle-leaf or coniferous woods, constitute by far the greatest amount of lumber used. The trees, with the exception of the junipers, bear distinct cones, and, excepting the bald cypress and the larches, have evergreen, or nondeciduous, foliage. The woods include the softest, lightest, and most easily worked kinds.

**White pine.** White pine (*Pinus strobus*), one of the most valuable timber trees of the world, was formerly more used than any other for general construction in the United States, and was largely exported. It forms great forests in Canada and the northeastern United States and also grows throughout the Appalachian Mountains southward to Georgia. The trees grow from 80 to 100 feet high, the trunks being from 3 to 9 feet in diameter. White pine has become scarce, and the lumber in A1 grades costs nearly as much as good mahogany. Sugar pine and other varieties of white pine grow in the region of the Rocky Mountains and the Pacific slope.

The soft, or white, pines are comparatively free from resin, are straight-grained, soft, and easily worked, and are suitable

for the cabinetmaker, the joiner, the carpenter, and the pattern-maker. The wood does not easily warp or check.

**Yellow pine.** Longleaf pine, hard, Southern, or Georgia pine (*Pinus palustris*), yields the best grades of yellow-pine lumber. It forms great forests not far from the seaboard from North Carolina to Texas. Large trees are as much as 90 feet high and 4 feet in diameter. This is the tree that yields turpentine.

FIG. 31. Lumber Mill on Puget Sound

These great fir logs are being floated down the Sound to the mills

Shortleaf pine, bull pine or spruce pine (*Pinus echinata*), occurs throughout the southeastern United States and plentifully in parts of Missouri, Arkansas, and Kansas. The wood is very similar to that of longleaf pine. Cuban, or pitch, pine (*Pinus cubensis*) is found near the coast from Charleston, South Carolina, to Mississippi, and also in the West Indies and Central America. The trees are somewhat larger than the longleaf pine, and the wood is hardly inferior. Loblolly pine (*Pinus tæda*) is scattered or in groves throughout the eastern United

States south of Maryland. Lumber known to the trade as North Carolina pine is cut almost entirely from this tree. Western yellow pine, or bull pine (*Pinus ponderosa*), is a large tree common in portions of the Rocky Mountains.

The hard, or yellow, pines are resinous, heavy, hard, strong, durable, and more difficult to work than the white pine. The wood is very commonly used for general building construction.

FIG. 32. Loading Hemlock Logs in West Virginia

American logging machinery makes it possible for a small crew to load large logs rapidly. These logs have been peeled, for the hemlock bark is important in the tanning industry

**Scotch pine.** Scotch fir, yellow deal, Baltic redwood, Danzig fir, Swedish fir, or northern pine (*Pinus sylvestris*), is in many ways the most important wood for ordinary purposes in Europe. There are large forests in Prussia, Poland, Russia, Norway, and Sweden. The wood is similar to American yellow pine. It is this tree which yields Russian turpentine.

**Kauri pine.** The kauri (*Agathis australis*) is the principal timber tree of New Zealand. The wood is intermediate in appearance and quality between white and yellow pine of

the United States. It is used locally and is exported to Europe. This is the tree which produces kauri resin.

**Spruce.** White spruce (*Picea canadensis*) has become an important timber tree since the white pine has been scarce. It is not found south of the fortieth parallel in the United States, but it forms vast forests throughout Canada as far north as Labrador and Alaska. The trees grow from 60 to 150 feet high, the trunks being from 3 to 5 feet in diameter. It is this species which is sold in the eastern United States for "Christmas trees." Black spruce is similar. Red spruce (*Picea rubra*) is a somewhat smaller tree, growing as far south as North Carolina, on the high peaks of the Alleghenies.

The spruces are valuable trees, furnishing soft, light, straight-grained white wood very free from resin. The wood is used commonly for construction, and it is used more than other kinds for making paper pulp. The lumber trade handles spruce under such names as Eastern, West Virginia, Adirondack, and Canada.

Tideland spruce (*Picea sitchensis*) is one of the largest and most important timber trees of the Pacific Northwest. The trees grow only near the coast from Alaska to California. They reach a height of from 200 to 300 feet.

Norway spruce, or European spruce (*Picea excelsa*), forms great forests in Europe. The wood is marketed under the name of "white deal." It is important for construction and paper pulp. Spruces are important timber trees in Manchuria and Japan.

**Hemlock.** Hemlock, or Eastern hemlock (*Tsuga canadensis*), is much used for framing-timbers: scantling, sheathing, etc. It occurs in southeastern Canada and the northeastern United States. Western hemlock (*Tsuga heterophylla*) is a larger tree and furnishes wood superior to that of the Eastern species.

The hemlocks are trees of high economic value and have become very important since the scarcity of pine. The wood

is splintery, pinkish-white in color, coarse-grained, and, though tough, is easily worked. It is one of the cheapest softwoods.

**Douglas fir.** Douglas spruce, Oregon fir or pine, or red fir (*Pseudotsuga douglasii*), is widely distributed in the northwestern United States and western Canada. It is a very large tree and supplies wood for general construction. It is the most important wood for masts, spars, and flagpoles. Noble fir (*Abies nobilis*), magnificent fir, and white fir are all large trees found from northern California to Canada.

European silver fir, or Swiss pine (*Abies pectinata*), grows in central Europe. It is important in the manufacture of musical instruments and toys. Japanese yew, Momi, is one of the most important timber trees of Japan.

**California redwood.** California redwood is one of the largest trees of the world and the most valuable on the California coast. It is closely related to the famous big trees of California and has wood very similar to theirs. The wood is especially valuable for shingles, tanks, coffins, and light construction. The trees (*Sequoia sempervirens*) grow from 200 to 300 feet high, with a diameter of trunk from 8 to 22 feet. The wood is very soft and light and of a dull-red color, is straight-grained, and does not warp or shrink readily.

**Larch.** Eastern larch, tamarack or hackmatack (*Larix americana*), is found in Canada and the northeastern United States. Western larch (*Larix occidentalis*) is abundant in the Northwest. The larches furnish wood that is strong and very durable. It is used for ship timbers, railroad ties, boat knees, etc. The trees grow as high as 150 feet.

European larch (*Larix europœa*) grows in the Alps of central Europe and in Lapland, Norway, and Siberia. Because of its durability the wood is used especially for piling. The tree yields Venice turpentine.

**Cypress.** Bald cypress, or red cypress, is common along the southern coast of the United States, particularly in swamps from Delaware to southern Texas and in the lower Mississippi

Valley. The tree (*Taxodium distichum*) grows from 80 to 140 feet high, with a diameter of trunk from 5 to 12 feet. Yellow cypress, or Alaska cedar (*Chamæcyparis nutkaënsis*), grows near the coast from Sitka to Oregon. "Cypress" is a rather general term for many woods allied to, or identical with, the cedars. The wood is distinctly grained, soft, coarse, and is used for cabinetwork, interior finish, shingles, framing, posts, etc.

Cypress of the Old World is a common tree of the Mediterranean region of Europe, Asia Minor, and Persia. Egyptian mummy cases were often made of this wood. Indian cypress grows in the Himalayas. Japanese sugi (*Cryptomeria* sp.) is a soft, straight-grained wood related to cypress. It is one of the most important timbers in the Far East.

**Cedar.** White cedar (*Chamæcyparis thyoides*) grows along the eastern coast of the United States from Maine to Mississippi. The trees grow from 50 to 70 feet high. Incense cedar (*Libocedrus decurrens*) is a common tree of Oregon and California which grows to large size. It is much used for lead pencils. Canoe cedar (*Thuya plicata*) is common in the Northwest from Alaska to California and Montana.

The white cedars are so called to distinguish the wood from that of the red cedars, or junipers. The trees are cut largely for posts, telegraph poles, fencing, and split shingles and are sawed into lumber for tanks, boats, and woodenware. The wood is very fragrant.

Cedar of Lebanon occurs in southwest Asia. Atlas cedar grows in the mountains of North Africa. Deodar is one of the chief timber trees of northwest India. Japanese fir, or hinoki (*Cupressus obtusa*), is an important timber tree. Arbor vitæ, common in Canada and the northeastern United States, is a lawn ornament and hedge tree.

Red cedar, or juniper, wood is fragrant, soft, light, and easily cut. It is used for lead pencils, woodenware, chests, cabinets, and fence posts. The tree (*Juniperus virginiana*) is found throughout the eastern and central United States. Haitian

cedar is identical. Western juniper of two related species is common in Washington, Oregon, and California.

Hardwoods are from broad-leaved trees which in temperate climates are deciduous; in the tropics, of course, most of these trees remain green throughout the year. They are of greater variety and wider distribution than are the coniferous trees, and the woods are more varied in grain, color, and texture. The extremes are reached in very white, jet black, rich red, and bright yellow, and they include the hardest and strongest woods.

**Poplar.** The so-called tulip poplar, or whitewood (*Liriodendron tulipifera*), is a tree of the first economic importance. It is the largest tree in the eastern United States, growing to a height of from 125 to 250 feet, with a diameter of trunk from 6 to 14 feet. The wood is variable, soft, easily worked, and yellowish-white shading to greenish or brownish in color. It is one of the most common woods for ordinary uses. (See Cottonwood.)

**Bass.** The lindens furnish soft, light, smooth wood of a light color. It is used for general construction and for many special purposes, such as carriage bodies, handles, cooperage, paper pulp, and gunpowder charcoal. American linden (*Tilia americana*) is common throughout southeastern Canada and the northeastern and central United States. It is also called basswood, lime, bee tree, lin, and whitewood. White basswood, or wahoo (*Tilia heterophylla*), is very similar. European linden, lime or lin, is of three species common in Europe. The wood is used for toys, carvings, druggists' boxes, etc.

**Cottonwood.** Cottonwood, or Carolina poplar (*Populus deltoides*), is similar to linden, and is used for much the same purposes. It is also used very extensively for paper pulp. It is found throughout the eastern and central United States, reaching its greatest development west of the Mississippi and in the South. The state of Mississippi is the largest producer. The trees grow from 80 to 175 feet high and from 4 to 8 feet

in diameter of trunk. The wood is soft, fibrous, light, and grayish-white or brownish. European poplar is of two kinds: black poplar, from the tree known in the United States as Lombardy poplar (*Populus nigra*), and aspen (*Populus tremula*), which comes mostly from the Baltic.

**Willow.** Willow (*Salix* sp.) is a wood which is easily worked. It is smooth and fairly strong. It is much used in Europe for cricket bats, toys, and small articles. It makes excellent charcoal. Young shoots, long and slender (osiers), are raised especially for the purpose of weaving basketry and for furniture.

**Maple.** Sugar, rock, or hard maple (*Acer saccharum*) grows along the Alleghenies from southeastern Canada to Georgia. This is the best and most important of all the maples. Michigan is the leading producer. Red, or swamp, maple (*Acer rubrum*), and silver, or soft, maple (*Acer saccharinum*) have a wider range but produce inferior wood. There is a maple (*Acer macrophyllum*) growing on the Pacific coast. Several species of maple grow in Europe, but the wood is not so good as that of American rock maple. Japanese maple is of excellent quality.

Maple wood is compact, tough, susceptible of a fine polish, and often beautifully grained, or figured, being then variously called curly, bird's-eye, blister, landscape, and fiddle-back maple. The wood is extensively used for veneering, flooring, furniture, the backs of violins, wooden bowls, shoe lasts, rulers, tool handles, and inlay work. It is especially valuable for charcoal.

**Birch.** Black, red, or cherry birch, American mahogany or mahogany birch (*Betula lenta*), is a good-sized tree growing commonly in the northeastern United States and southern Canada. Wisconsin leads in the production of this lumber. The wood is hard, strong, fine-grained, reddish in color, often fairly well figured, and sometimes shows beautiful wavy grain (curly birch). It is much used in furniture, doors, window frames, etc. and is usually stained and finished to imitate mahogany. It is

used for making handles, clothespins, shoe pegs, woodenware, wheel hubs, fruit and berry baskets, and boxes.

A great deal of "ply wood" is on the market. This consists of three or more thin sheets of wood glued together, generally with the grain running in different directions. A common type is made of a poplar core perhaps three eighths of an inch thick with birch veneers of one-sixteenth inch glued on both surfaces.

Yellow birch (*Betula lutea*) furnishes wood that is lighter in color than black birch. White birch, or paper birch (*Betula papyrifera*), is less important. The bark of this tree is peeled off and used for making canoes and fancy articles. European birch (*Betula alba*), of northern Europe and Asia, is very similar to American cherry birch.

**Beech.** Beech (*Fagus americana*) is very common in southern Canada and the eastern and central United States. It is a hard, strong, fine-grained wood of a pinkish-brown color, used for tool handles, clothespins, wagon stock, shoe lasts, and gunpowder charcoal.

European beech (*Fagus sylvatica*) is common except in Scandinavia and eastern Russia. This is a very important wood in Europe for general purposes. It is cultivated in large artificial forests. Sabots (wooden shoes) are often made of it.

**Sycamore.** Sycamore, or buttonwood (*Platanus occidentalis*), is valued chiefly for interior decoration. It is common from Maine to Florida and from Nebraska to Texas. The wood is light reddish-brown, rather hard, unevenly grained, and difficult to work. When cut radially it shows a beautiful mottled figure known as lacewood or honeysuckle. The plane tree (*Platanus orientalis*) of Europe supplies wood almost exactly like American sycamore.

**Oaks.** Oaks are of many species, but American lumbermen recognize only three important types: white oak, red oak, and live oak. Quartered oak, often very highly figured, is used for decorative work; plain-sawed, or straight, oak is used where strength and durability are the important factors. The various

shades of finished wood in furniture, cabinetwork, and interior decoration, such as "golden" oak, "green" oak, "antique," "old English," "Tuscan," and so on, are entirely the result of fillers put on to close up the pores before the varnishes are applied.

White oak (*Quercus alba*) is common from Maine to Michigan and Missouri and from Florida to central Texas. The trees grow from 80 to 150 feet high, and the trunks from 4 to 8 feet in diameter. The bark is used for tanning. The wood is hard, tough, strong, elastic, and durable. It goes into interior finish, flooring, furniture, cooperage, agricultural implements, bridge and building timbers, etc.

Burr oak, or mossy-cup oak (*Q. macrocarpa*), overcup oak (*Q. lyrata*), chestnut oak (*Q. prinus*), yellow oak (*Q. prinoides*), basket, or cow, oak (*Q. michauxii*), swamp white oak (*Q. bicolor*), Oregon white oak (*Q. garryana*), and tanbark oak (*Q. densiflora*) all furnish wood of the type of white oak.

Red oak is somewhat softer, more open-grained, and less durable than white oak. The heartwood is of a decided pink or light-red color. It has much the same general uses as white oak. The trees grow throughout the eastern and central United States. The following species furnish lumber: red oak (*Quercus rubra*); Spanish oak (*Q. digitata*); black oak (*Q. velutina*), also called yellow-bark and quercitron oak; pin oak, or swamp Spanish oak (*Q. palustris*); willow oak, or peach oak (*Q. phellos*).

Live oak is less commonly used. Southern live oak (*Quercus virens*) grows from Virginia to Mexico. Western live oak is found in Oregon, California, and Arizona. The wood is exceptionally hard, tough, strong, and durable. It is used for shipbuilding, wagons, agricultural implements, etc.

Old World oaks yield wood very similar to that of the American species. There is a large commercial production of oak lumber in many parts of Europe and Asia. Russia, Austria, Hungary, and Germany all export oak wood. England im-

ports oak from Japan and a wood called oak (*Casuarina*) from Australia. The United States exports oak in various shapes.

English oak, also known as European and durmast oak (*Quercus robur*), is common throughout Europe, Syria, and North Africa. Turkish oak of middle and southern Europe and western Asia is also known as Adriatic, iron, and wainscot oak (*Quercus cerris*). There are several species of important timber oaks in India (Himalayan region) and several in Japan. Several trees in Australia and Africa are known as oaks but do not belong to the same family. They have been so named only because they have strong, hard, useful wood.

**Ash.** White ash (*Fraxinus americana*) grows throughout the eastern and central United States from southeastern Canada to Minnesota and Texas. Red, green, black, and blue ash are all small or medium-sized trees growing in the eastern or central United States. Oregon ash grows from Washington to California along the coast. Ash is particularly strong and elastic and is comparatively light in weight. It is used for agricultural implements, wagons, oars, boat-building, furniture, and interior decoration.

European ash (*Fraxinus excelsior*) is a native of all Europe and North Africa. Curly forms of the wood that are much prized for furniture occur in Hungary and are imported to the United States. Ash is a fairly common wood in Japan and northeastern Asia.

**Chestnut.** The chestnut (*Castanea dentata*) is a large tree common from Maine to Tennessee. The wood is relatively soft, light, and open-grained. It resembles plain-sawed oak and is very commonly used for furniture and interior finish. A very important tanning extract is made from this wood.

European chestnut, or Spanish chestnut (*Castanea sativa*), is very similar, but the wood is less important.

**Elm.** White elm (*Ulmus americana*) grows from southern Newfoundland to the Canadian Rockies, as far south as Florida and northern Texas. Rock elm, or cork elm (*Ulmus race-*

*mosa*), red, or slippery, elm, cedar elm, and winged elm, or wahoo, are other species. English elm (*Ulmus campestris*) grows throughout Europe.

Elm is a very desirable wood for special purposes. It is similar to ash, but is tougher, stronger, equally elastic, and even easier to work. It is used for boat-building, wagon spokes, fellies, the rims of wheels, agricultural implements, butcher blocks, tool handles, cooperage, etc.

**Hickory.** Hickory grows from southern Ontario to Minnesota, Florida, and Texas. Arkansas cuts more of this wood than any other state. Shellbark, or shagbark, hickory (*Hicoria ovata*), mockernut, king-nut, bull-nut, or whiteheart, hickory (*Hicoria alba*), and pignut, brown, or black, hickory (*Hicoria glabra*) are common species.

Hickory is one of the toughest of woods and is therefore much used for purposes where strength is necessary. It is used for wagon axles, spokes, and fellies; ax, pick, and hammer handles; baseball bats, agricultural implements, etc. The white sapwood is generally preferred to the darker heartwood.

Pecan (*Hicoria pecan*) is common from Indiana to Nebraska and southern Texas. The wood is somewhat inferior to shellbark hickory, but the nut is superior to all other species.

**Locust.** Locust is useful for fence posts, railroad ties, sills, etc. because of its great durability in contact with the soil. The common locust (*Robinia pseudacacia*) and the honey locust (*Gleditschia triacanthos*), both medium-sized trees, are common in the eastern central United States. Locust wood is of more importance in Europe than in the United States, being used for furniture and for shipbuilding.

**Walnut.** Black walnut (*Juglans nigra*) is a dark-brown wood, often with a purplish tone. It is moderately hard, is strong, is easily worked, and "stands" well. The trees are found from Massachusetts to Florida and from Minnesota to central Texas. Occasionally the trunks are 150 feet high. This tree was formerly very common, but it is now rather

scarce, and the wood has risen greatly in price. It is used for gunstocks and for airplane propellers, furniture, and musical instruments.

Walnut (*Juglans regia*) grows in many parts of Europe and Asia. It comes on the market as French, English, Italian, and Circassian walnut. The commercial sources of this important lumber are the shores of the Black Sea and the district east as far as Persia and India. Much of the best is cut in the Caucasus and is shipped from Odessa to Liverpool and London. The Circassian wood is often beautifully figured and is much used in veneers.

Butternut, white walnut or white mahogany (*Juglans cinerea*), is similar to walnut but is softer and of a light pinkish-brown color. It grows from southern Canada and Minnesota to Mississippi and Arkansas.

**Cherry.** Wild black cherry (*Prunus serotina*) grows from Ontario to Florida and from Dakota to Texas. The wood is light-reddish, turning darker with age (it is commonly stained a deep red). It is prized because of its hardness, color, beauty of grain, close texture, and stability. These qualities make it suitable for cabinetwork, scientific-instrument bases, printer's furniture, pattern-making, and turning. The supply has decreased greatly and the price has advanced, so that this wood is now little used.

**Red gum.** Red gum, or sweet gum (*Liquidambar styraciflua*), is a tree of great economic value, the wood being used for cabinetwork, interior finish, fancy boxes, log-turned basket and box veneers, cooperage, and to some extent for building. It is sold under various names: "hazel," "satin walnut," "bilsted," etc. The wood is not heavy or hard and is of a light-brown color. The tree is common from New Jersey to Florida and from Missouri to southern Mexico. Arkansas is the largest producer of this lumber.

**Tupelo.** Tupelo, or gum (*Nyssa* sp.), is marketed from Louisiana and adjacent states. The wood is light, soft, and

tough and is used for wheel hubs, rollers, woodenware, fruit boxes, crates, etc. This wood is often confused with red gum.

**Less common woods of the temperate zone.** Holly is a rather small tree the very white, close-grained wood of which is used for fancy articles, turning, fret-sawing, and inlay work. American holly (*Ilex opaca*) grows from Massachusetts to Missouri and from Florida to eastern Texas. European holly is found in central Europe and western Asia.

Dogwood, American boxwood or cornel (*Cornus* sp.), is a white, close-grained wood used for making shuttles for weaving.

Apple, pear, peach, and orange woods are compact and fine-grained. They are used in a limited way for engraving etc.

**Mahogany.** Mahogany is a word used in a general way as a trade term, meaning any wood which has a color, grain, and general appearance more or less like that of real mahogany. The name is applied by dealers to woods from several entirely different families of trees. Men in the trade usually classify woods of this general type as (1) mahogany, (2) Spanish cedar, and (3) baywood. "American mahogany" is another name for birch.

True mahogany, or caoba (*Swietenia mahogoni*), is a fairly hard wood of good reddish color, moderately porous, and often displaying a beautiful figure. If properly seasoned it "stands" remarkably well without warping, shrinking, or cracking when exposed to heat, cold, or dampness. For this reason it is considered especially valuable for making propeller blades for airplanes. It is the popular wood for fine furniture, for interior finish in houses, offices, railway cars, and ship's cabins, for musical, electrical, and optical instruments, and for other high-class ornamental work.

A great deal of figured mahogany is used in the form of thin veneers glued on the face of cheaper mahogany or on other woods. Some of the most beautiful veneers are sawed from wood which formed the junction of a limb with the trunk of a tree. These crotch veneers display remarkably fine figure.

When freshly cut, mahogany has usually a fairly light pinkish color which becomes dark red on exposure to light. Old mahogany takes on a rich deep color, which is generally imitated on new work by red stain filler which closes the pores.

In the American trade the wood from Santo Domingo ranks as the best, but the supply is small. Cuban mahogany is of high quality, and much of the Mexican goes into almost as good a class. Honduras, Costa Rica, Nicaragua, Panama, Colombia, and Venezuela all export mahogany, some of which is good hard wood, but these kinds bear in general the reputation of being poorly figured and are less popular.

African, or Gambia, mahogany (*Khaya senegalensis*) is exported from the west coast of Africa along the Gulf of Guinea. It is much used in Europe. American buyers usually class it as inferior to West Indian and Mexican mahogany, because it is softer and coarsely grained, although it is often richly colored and beautifully figured.

Colombian mahogany (*Cariniana pyriformis*) is a hard wood, often well figured, and greatly resembles true mahogany. This and the woods of several other entirely different trees come on the market as South American mahogany.

Philippine mahogany (*Shorea* sp.) and *palo maria* (*Calophyllum inophyllum*) are light-colored, fairly hard Philippine woods. They can easily be stained red, are often well figured, and have in many respects the same characteristics as mahogany. Among the many other woods which are either called mahogany or which resemble it are several kinds of eucalyptus from Australia.

**Woods resembling mahogany.** Spanish cedar (*Cedrela odorata*) is known under the names of various producing localities in Spanish America, being marketed as Mexican cedar, Honduras, Cuba, or West Indian cedar, etc. It is also called cigar-box cedar or cedro. It is softer than mahogany, is not so strong, and has a more open grain. Much of this wood is straight-grained, but it is sometimes beautifully figured. It is

in general cheaper than mahogany but is, nevertheless, a valuable decorative wood used in very large quantities. Like true cedar it is aromatic and is rather soft and easily worked.

The woods from several different trees in various parts of the world are of this general type, varying slightly in hardness and other characteristics. The following are important: toona mahogany, or Australian red cedar (*Cedrela toona* or

FIG. 33. Logging Train in Greenville, Mississippi

The "caterpillar" has wonderful power and does not demand good roads. Lumbermen seek the cheapest means of transport from the forest to the mill

*Toona australis*), a common wood in Queensland and New South Wales. This wood is used for some of the cheaper mahogany furniture in the United States. It is probably identical with Moulmein cedar, or Indian mahogany, and also with Philippine calantas. Argentine and Brazilian cedar are closely related to Spanish cedar. West African cedar, Gabun cedar or okoume, from French Congo and Sierra Leone, is a wood of similar qualities, but from trees of very different species. These "cedars" come on the market in larger lumber, as a rule, than true mahogany, and the best of them are difficult to distinguish from it.

Baywood is regarded by American dealers as a very inferior article. It is light in weight and color, soft, open-grained, porous, and lacking in strength. It is sometimes called Honduras swamp mahogany. Some lumber dealers believe that baywood comes from trees of the same species as true mahogany but that its inferior quality is due to rapid growth in hot, swampy land.

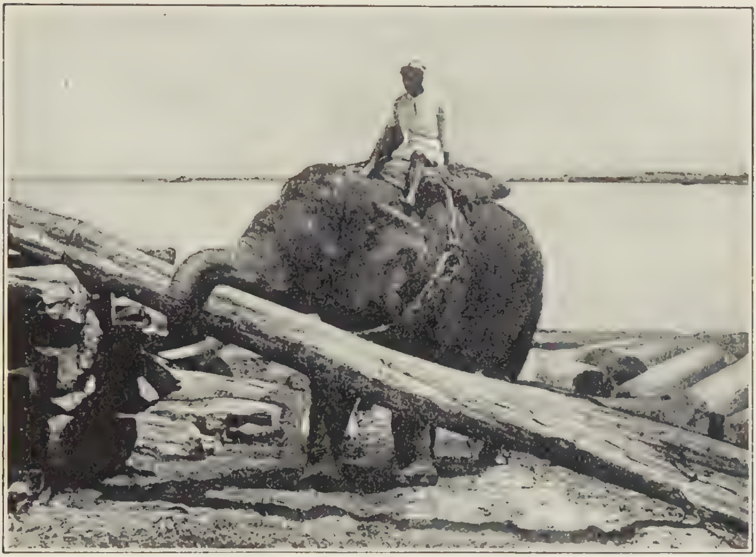


FIG. 34. "A-Pilin' Teak," Rangoon, Burma

Teak logs from forests up the Irrawaddy River are still carried and piled by elephants in these timber yards. Rangoon is the principal teak market of the world

White mahogany, or primavera (*Tabebuia* sp.), is a cream-colored wood with a grain much like mahogany. It is often beautifully figured. It comes from southern Mexico, Central America, and northern South America. The name "white mahogany" is sometimes applied to butternut.

Padauk, vermilion wood, Andaman redwood, or Indian mahogany (*Pterocarpus indicus*), is a very handsome figured wood suitable for the finest cabinetwork. It is produced in the Anda-

man Islands. This wood is called narra in the Philippines. It is a trifle harder than mahogany.

Sabicu (*Lysiloma sabicu*) of Cuba is in many ways similar to mahogany, but its color is brown. Crabwood of Guiana and andiroba (*Carapa guaianensis*) of Brazil are reddish-brown woods useful for furniture.

**Teak.** Teak, or Indian oak (*Tectona grandis*), is native in India, Burma, Siam, the Malayan islands, and the Philippines, and is extensively exported to Europe and the United States. The most important teak forests are in the region drained by the Irrawaddy River, with Rangoon as the great shipping point. Much comes from Siam, Java, and the Straits.

Teak is the best timber for shipbuilding and for backing armor plates, since it does not, like oak, corrode the iron. It is used for piling and wharves and is also largely used for railroad cars, flooring, gunstocks, and furniture. The wood is light-brown, open-grained, somewhat oily, fragrant, strong, and durable.

**Greenheart.** Greenheart, or Demerara greenheart (*Nectandra rodiœi*), is a wood which comes from British Guiana. It is wonderfully strong and durable and is especially valuable for shipbuilding, dock construction, lock gates, bridge work, piling, fishing-rods, etc. Bethabara, or Surinam greenheart (*Tecoma araliacea*), is similar to greenheart in many ways but is not proof against the shipworm.

**Lignum-vitæ.** Lignum-vitæ (*Guaiacum officinale*) is a very heavy, hard, resinous wood from the West Indies, especially Santo Domingo and Cuba. It grows also in Central America. It is used for bearings of engine shafts on steamships and for pulley blocks, tool handles, caster wheels, and balls for bowling.

**Rosewood.** Rosewood is a name applied to several different woods (mostly species of *Dalbergia* and *Machœrium*). The wood is hard, heavy, and usually fragrant; its color is brown, streaked with dark brown, purple, or black. It takes a handsome polish. Brazilian rosewood, or jacaranda, is exported

from São Salvador (Bahia) and Rio. Indian rosewood, or Bombay blackwood, Madagascar rosewood, and Honduras rosewood are of different species. An essential oil with the odor of roses is distilled from Guiana rosewood.

**Various tropical woods.** Granadillo, or cocus (*Brya ebenus*), is a red-and-black striped wood of the West Indies. It is used for tool handles. Cocobolo (*Dalbergia retusa*) and cocoloba of Central America are similar.

Tulip wood (*Physocalymma* sp.) is a showy pink-and-yellow striped wood from Brazil.

Zebra wood is a beautiful striped wood from Central America and northern South America. Several very different woods go by this name, among others Guiana zebrawood (*Connarus guianensis*) and Andaman ebony, or marblewood.

Leopard wood, letterwood, snakewood (*Brosimum aubletii*), is a mottled red wood from Guiana. Partridge wood, or coffee wood (*Cæsalpinia granadillo*), is a striped brown wood from Venezuela. It is used for umbrella handles and canes and for the backs of brushes. Acapú from Brazil is similar. Roble colorado, or vencola, from Venezuela is used chiefly for turnings.

Amaranth, purpleheart, and violet wood (*Copaifera pubiflora, Peltogyne* sp.) are rich purple woods from northern South America.

Beefwood, or bullet wood, is from the tree *Mimusops* sp., which yields balata in Guiana. Massarandubá of the Amazon is practically identical.

Ebony is the hard, dense, black heartwood of various trees, mostly of the persimmon family (*Diospyros* sp.). The logs have a considerable quantity of yellowish sapwood, which is generally cut away before they are sent to market. The commercial supply is mainly from the Gabun coast (French Equatorial Africa). Some is shipped from Madagascar, India, Ceylon, Burma, and Siam.

Related woods, brown in color or streaked with black, are produced in many countries. Macassar marblewood and An-

daman ebony are of this nature. Camagon from the Philippines is much used for umbrella handles; kaki wood of Japan is similar. American persimmon wood is used for shuttles, for shoe lasts, etc.

Green ebony comes from India, Brazil, and the West Indies. The wood is hard and compact, of a dark-green color, and comes from several different trees.

"Satinwood" is a name given to two different woods, both of which are close-grained and have a yellow color, a beautiful figure, and a shiny luster when polished. The wood is used for making backs for brushes and for inlaying furniture. West Indian satinwood (*Xanthoxylum* sp.) is from Santo Domingo, the Bahamas, Jamaica, and Cuba. East Indian satinwood (*Chloroxylon swietenia*) is from Ceylon and India. Brazilian satinwood, or sateen wood (*Euxylophora parœnsis*), is similar in appearance.

Boxwood, or Turkey boxwood (*Buxus sempervirens*), is a very fine, close-grained yellow wood which grows in Asia Minor, Persia, India, and southeastern Europe. It is used for wood engraving, for inlaying, and for rules, mathematical instruments, shuttles, etc. Rule boxwood, or West Indian boxwood (*Casearia prœcox*), is a wood of the same character from northern South America and the West Indies. Similar woods grow in South Africa (Cape boxwood) and China.

Sandalwood (*Santalum album*) from Mysore, India, and the islands of the Pacific is a fragrant yellow wood used for fancy articles. It is valued chiefly for making incense and as a source of an essential oil. Madras is the chief market. Many other fragrant woods go under this name.

Lancewood (*Oxandra lanceolata*) is a yellow wood from Honduras. It is used for fishing-rods, bows for archery, etc. Cuba, Jamaica, and Guiana also supply it. Degame from Cuba is similar.

**Miscellaneous woods.** Olivewood (*Olea europœa*) is a streaked yellow-brown wood used for making small fancy

articles. It comes from Mediterranean countries and is from the tree that produces olives.

Black palm from Panama is fairly important for fishing-rods. Coconut, or porcupine, wood (*Cocos nucifera*) is used in small quantities.

Brierwood (*Erica arborea*), for making pipes, comes from France and other parts of southern Europe.

"Ironwood" is a name applied to a score or more of woods from almost all parts of the world. They are alike in only one respect—their great hardness.

Camphorwood (*Cinnamomum camphora*) is a fragrant, light-colored, rather soft wood from Taiwan (Formosa), Japan, and China. Little is obtainable in lumber, for the wood yields camphor by distillation.

Jarrah (*Eucalyptus marginata*) of Australia is a hard, heavy, dark-red wood. The lumber is very durable and is often exported in the shape of wooden paving-blocks. Karri (*Eucalyptus diversicolor*) is similar to jarrah. Others of the Australian eucalyptus woods go under such names as "blue gum," "iron bark," "blackwood," "silky oak."

Balsa wood (*Ochroma lagopus*) is cut in Central America, in northern South America, and in the West Indies. It is the lightest known wood, but is fairly strong and has been used in airplane construction and for life-preservers. In equal bulk spruce wood weighs four times as much. Locally balsa wood is used for canoes.

**Cork.** In one European species of oak (*Quercus suber*) the bark is unusually thick and spongy, and the outer layer can be stripped off without injury to the tree. The product of the first stripping, called virgin cork, is rough. It is used chiefly for tanning and, by florists, for decorative purposes. In from six to ten years another layer can be removed. The best cork comes from old trees. It is taken off in large sheets, dipped in hot water, pressed flat, dried, and baled for shipment. Corks are cut by machinery, and the cuttings and waste are used in

making linoleum and other floor coverings, life-preservers, pipe covering and other heat-insulators, for packing grapes, and for making burnt cork. Thin sheets of cork are used in shoe soles for lightness and warmth. Tropical helmets are often lined with cork. Cork is produced principally in Portugal, Spain, southern France, Italy, Greece, Austria, Morocco, Algeria, and Tunisia.

**Pith.** Pith from sola, a swamp weed (*Æschynomene aspera*), is used in India for making sun helmets.

Rice paper is not paper and is not made of rice. It is thin shavings of pith from a small Taiwan (Formosa) tree (*Fatsia aralia papyrifera*) cut by the Chinese. There is also paper made of rice straw.

**Wood distillation.** When wood is heated in a retort various gases are driven off. Some of these gases when passed through cooled pipes become condensed into a liquid, and charcoal is left in the retort. By redistillation and treatment with certain chemicals the liquid may be made to yield a variety of useful substances, as is shown in the accompanying diagram. Oak, maple, birch, beech, and pine are the kinds usually distilled.

- Wood
  - Charcoal
  - Liquid
    - Pyroligneous acid, or wood vinegar
      - Crude wood spirits
        - Ammonia
        - Wood alcohol
        - Acetone
      - Acetates
        - Acetate of lime
        - Sugar of lead—Alum mordants
        - Acetic acid
        - Acetone—Chloroform
      - Tar
    - Tar
      - Creosote
      - Pitch
  - Gas

The uses of these products are as follows: charcoal, for fuel, filtering, gunpowder, etc.; gas, for fuel; ammonia, for chemical manufacture and household uses; wood alcohol, in varnishes and for burning, making aniline colors, etc.; acetates, for dyeing, calico-printing, medicine, etc.; acetic acid, for a great variety of purposes in chemical manufacture; acetone,

for preparing chloroform, iodoform, sulphonal, smokeless powder; chloroform, as an anæsthetic, a solvent for resins, etc.; creosote, as an antiseptic, medicine, and preservative; tar, as a preservative; pitch, for shipbuilding, roofing, etc.

**Charcoal.** Charcoal is very commonly made without saving the by-products. In Sweden it is used for blast-furnace fuel and to produce iron and steel low in phosphorus. The shells of coconuts, peach kernels, and other nuts are burned to make a charcoal which has remarkable powers of absorbing certain gases. This charcoal is used in gas masks.

**Lampblack.** Lampblack, for printer's ink, paint, etc., is soot obtained by burning resinous wood in a smoldering fire in a specially constructed furnace.

**Potash**. Formerly almost the only way of obtaining potash was by dissolving it out of wood ashes. It is now prepared by chemical processes from various materials.

Vegetable matters, such as sawdust, straw, or bran, when heated with caustic potash form oxalates which on treatment with sulphuric acid yield oxalic acid. This acid and its salts are used chiefly in bleaching and dyeing.

## DYESTUFFS

The vegetable dyestuffs are woods, barks, leaves, flowers, or whole plants, which, when treated with hot water, form a solution that can be used to color yarns, fabrics, leather, and wood. Some animal and mineral substances have similar properties. Many dyestuffs are handled commercially in the form of extracts, made by dissolving the dyeing principles and concentrating the liquor into a thick paste or a dry condition.

Natural dyestuffs are of much less importance now than in the past, for coal-tar dyes have largely taken their place. While it is true that some coal-tar dyes are of poor quality, this is equally true of many vegetable dyes. It is also a fact that there are a great many first-class coal-tar colors, brighter, more intense, and faster than vegetable dyes. In addition coal-

tar dyes can be obtained in a much greater variety of color. These facts explain their wide use. Coal-tar dyes have not entirely superseded all others in commerce, but they are far more important than all others combined. Germany practically controlled the trade in these colors before the World War, but the United States, France, and England now produce them in large amounts.

Of the mineral dyes the following are important: chrome yellow, chrome green, iron buff, iron gray, manganese brown, Prussian blue, etc.

Many excellent dyes will not stain fibers until after the latter have been treated with some other liquid, known as a mordant. Thus logwood or its extract is used only after the fabric has been boiled in a solution containing some chemical. Turkey-red oil, alum, tannin, argols, and compounds of soda, tin, chromium, and iron are the common mordants. Some color effects are obtained by dyeing a fabric and then applying a chemical which removes the color in stripes or figures. This is called discharging the color.

Dyes are classified as follows: (1) "Acid" when they work best in an acid bath. These are used chiefly for wool and silk. (2) "Basic" when they work best in an alkaline bath. These are usually employed in connection with a tannin solution for dyeing wool, silk, or cotton. (3) "Substantive," which dye fabrics of cotton or silk or wool without a mordant. These are used chiefly for cotton. (4) "Mordant" dyes, which will not stain satisfactorily without a mordant.

The dyeing industry uses large quantities of chemicals, such as alum, salt, bleaching powder, chloride of lime, soda ash, soap, caustic soda and potash, sodium hypochlorite, ammonia, lime, Glauber salt, tartar emetic, tannin, sulphuric acid, nitric acid, hydrochloric acid, acetic acid, and salts of chrome, tin, iron, and copper.

**Logwood.** Logwood, or campeche, is the dark-red heartwood of a tree (*Hæmatoxylon campechianum*) that grows in

Mexico, Central America, and the West Indies. The principal commercial sources are Yucatan, Honduras, Haiti, and Jamaica. The wood comes to market in logs from five to ten inches in diameter from which the bark and the sapwood have been removed.

Logwood extract is made in the West Indies as well as in America and Europe. This reddish coloring matter has no direct affinity for fibers and requires the use of a mordant, the color obtained depending on the mordant used. It is largely used for dyeing silk black, but it also gives shades of blue, gray, and violet. Commercial preparations are in both liquid and powder form and are sold on the basis of their content of hematine (the active dyeing constituent).

**Brazil wood.** Brazil wood, or Pernambuco wood, comes from South and Central America. As in logwood, the heartwood of the tree (*Cæsalpinia*) is used, and the coloring matter is extracted with boiling water. It gives shades of red and violet but does not alone produce fast colors. The wood is used for violin bows.

**Various dyewoods.** Hypernic, peachwood, brasiletto, Nicaragua wood, or Lima wood, is a red dyewood (*Hæmatoxylon brasiletto*) closely related to brazil wood, chiefly from Central America. The name "hypernic" is by some restricted to the extract from red dyewoods.

Sappan wood (*Cæsalpinia sappan*) is a similar wood from India. Red sandalwood, red sanders or saunderswood (*Pterocarpus santalinus*), is from the East Indies and Madagascar.

Camwood, or barwood (*Baphia nitida*), is from Sierra Leone and other parts of West Africa.

**Fustic.** Fustic, mora, Cuba wood, yellow wood, or old fustic, is from a tree (*Chlorophora tinctoria*) growing in the West Indies and tropical America. It is used in dyeing woolen goods, giving a bright-yellow color.

Young fustic is the wood of the Venetian sumac tree (*Rhus cotinus*). The leaves of this tree are used in tanning. Osage

orange wood (*Toxylon pomiferum*) is cut in Arkansas, Oklahoma, and Texas. The extract is called aurantine.

**Quercitron.** Quercitron is the bark of the yellow-bark oak tree (*Quercus velutina*) collected chiefly in Georgia, the Carolinas, and Pennsylvania. It yields a yellow dye and is also used in tanning. Extract of quercitron is sold under the name of "flavine."

**Madder.** Madder is a powder made from the dried roots of a plant (*Rubia tinctorum*) that is cultivated in southern Asia and central Europe. It furnishes a red dye used for cotton goods, which is of decreasing importance owing to the use of coal-tar colors. Commercial grades are Levant, Alsace, Avignon, and Dutch. The plant has been little cultivated in recent years because alizarin prepared from coal tar is identical with the coloring principle of madder and is cheaper.

**Dyes from flowers.** Saffron, or crocus, is the dried flowers of a bulbous plant (*Crocus sativus*) coming chiefly from Greece, Turkey, and Spain. Safflower (*Carthamus tinctorius*) is the dried flowers of a plant cultivated in India and Persia. American saffron is from Mexico. Turnsole (*Croton tinctorius*) is from southern France.

**Henna.** Henna leaves (*Lawsonia alba*) are gathered in Egypt, Persia, and India. Outside of those countries this orange dye is little used. It does go into some toilet preparations.

**Annatto.** Annatto furnishes a harmless yellow dye used chiefly in coloring butter and cheese. It is obtained from the pulp which surrounds the seeds of a shrub (*Bixa orellana*) cultivated in South and Central America and the West Indies. The pulp is washed from the seeds by water and is then separated and dried. It comes on the market as a red or orange liquid or paste. The dried seeds, with pulp adhering, are also exported.

**Indigo.** Indigo is a blue dye obtained from the juice of the indigo plants (mostly *Indigofera* sp.), which grow in tropical countries. India, Ceylon, Java, and Central America are the chief producers. The freshly cut plants are soaked in water,

which absorbs the juice, becoming greenish in color. On exposure to the air it turns blue, and the indigo separates, falls to the bottom of the tank, and is dried. Commercial grades are named Madras, Bengal, Calcutta, Kurpah, Java, Manila, and Guatemala.

For dyeing, indigo is usually acted on by some chemical, such as soda or potash, which reduces it to a colorless substance known as indigo white. This is more easily soluble than blue indigo, and the materials to be dyed are dipped in a solution of this substance. Upon exposing the fabrics to air the indigo white changes again by oxidation to indigo blue. In printing calicoes, indigo white is thickened with gum, dextrine, or starch. "Bluing," for laundry use, is frequently indigo.

The manufacture of artificial indigo from coal tar has made the growing of indigo unprofitable in the West Indies and northern South America, where large quantities were formerly produced.

Woad, weld or wold (*Isatis tinctoria*), is a blue dye that was much used in England several hundred years ago but is employed little today.

**Other vegetable dyes.** Orchil, orchilla, orseille or archil, is a lichen (*Roccella tinctoria*) gathered on the coasts of the Canary and Cape Verde islands. It is used for dyeing silks in shades from red to yellow. Cudbear (*Lecanora* sp.) and litmus (*Roccella* sp.) are similar lichens.

Alkanet is from a root (*Alkanna tinctoria*). It is used chiefly for coloring cosmetics. It comes from southern Europe and Asia.

Persian berries, or yellow berries (*Rhamnus infectoria*), come chiefly from Black Sea ports.

Various other vegetable products are used in dyeing, such as turmeric, cutch, dragon's blood, gamboge, etc.

**Cochineal.** Cochineal consists of the dried bodies of female insects (*Coccus cacti*) that belong to the plant-lice family and live on cactus plants in Mexico and Central America. They have been introduced into Algeria, the Canary Islands, Ten-

erife, and the East Indies. The insects are collected and killed by placing them in hot ovens, when they become coated with a waxy whitish powder (silver cochineal). When killed in hot water or by steam they are black and are not so valuable. The principal use of cochineal is as a dye for woolen fabrics. The color is known as carmine and is soluble in water; with alumina and tin salts scarlet lakes are formed. These are used for oil and water-color pigments.

**Other animal dyes.** Kermes is similar to cochineal in being the dried bodies of insects (*Coccus* sp.). It is found on oak trees in southern Europe.

Lac dye. See Shellac.

Sepia is a brown dye used chiefly in water colors. It is prepared from the ink bag of a species of cuttlefish (*Sepia officinalis*) caught in the Mediterranean. The historic Tyrian purple was obtained from a Mediterranean shellfish.

## TANS

Tans include all substances which by acting on the fiber of skins and hides render them proof against the ordinary process of decay and at the same time make them pliable. Most of the vegetable substances that are used to convert skins and hides into leather contain an astringent principle called tannin. Vegetable tannins are valued especially for the tannage of sole leather, belting, and harness leather. The use of chrome (bichromate of potash) for tanning kid leather is very common. Many other substances are used by tanners in preparing skins and leathers for market, such as lime for unhairing, acids, sodium salts, alum, dog's dung, bird's dung, bran, lampblack, oils, egg yolk, dyes, varnishes, etc. Many substances, such as cutch and quercitron, are used both in tanning and dyeing.

**Chestnut wood.** Chestnut wood (*Castanea dentata*) furnishes more than half the tannin now used in the United States. The extract is prepared mostly in North Carolina, Virginia, and Tennessee. It is made also in France, Italy, and Hungary.

**Hemlock bark.** Hemlock bark (*Tsuga* sp.) was for many years the most important tanning material in this country. The bark and the extract are produced in Pennsylvania, Wisconsin, Michigan, New York, West Virginia, and Maine. The Western hemlock is not used very extensively as yet.

**Oak bark.** Oak bark and the extract are from various species (*Quercus*). The chestnut oak (*Q. prinus*) is most important in the East (Virginia, West Virginia, Tennessee, North Carolina). In Oregon and California the tanbark oak (*Q. densiflora*) is much used. Oak bark for tanning is produced in England, Belgium, Holland, France, and Sweden. Extract from oak wood is made in Hungary and Italy.

Pine, spruce, fir, larch, birch, willow, and other barks contain tannin and are used in Europe.

**Quebracho.** Quebracho extract is obtained by boiling chips of a hard red wood (*Schinopsis lorentzii*) which grows in Argentina and Paraguay. It is much used in Europe and the United States. Quebracho wood makes very durable railway ties.

**Mangrove bark.** Mangrove bark is obtained from trees (*Rhizophora* sp.) which grow on swampy coasts throughout the tropics. Barks or extracts are exported from East Africa, Madagascar, the East Indies, Borneo, Celebes, Venezuela, Colombia, Brazil, and the West Indies. The solid extract is often called mangrove cutch. Mangrove is increasingly important in tanning.

Wattle bark, or mimosa (*Acacia* sp.), is from Australia and from Natal (Union of South Africa).

**Sumac.** Sumac (or sumach) leaves are obtained from several species of sumac (*Rhus*). They are largely imported as ground sumac, the commercial grades being Sicilian, French, Tyrolean, Venetian, and Virginian. European sumac is richer in tannin than the domestic. It is used in tanning fancy leathers and in dyeing.

**Cutch.** Cutch is a dark-colored extract which usually comes in large cakes wrapped in palm leaves. Catechu is from the heartwood of a tree (*Acacia catechu*) common in India and

Ceylon. It is largely exported from Pegu, Burma. Bombay cutch is from a palm (*Areca catechu*); Bengal cutch is from a mimosa (*Mimosa catechu*). (See also mangrove cutch, under Mangrove bark.)

Gambier, gambier cutch or terra japonica, is an extract from the leaves of a bush (*Uncaria gambier*). It is exported chiefly from Singapore. It comes in large blocks and in cubes about an inch across (cube gambier). It is used in tanning soft sheepskin leather and in dyeing.

Kino is a dried juice used for tanning, dyeing, and medicine. The chief kinds in commerce are Amboyna, or Malabar, kino (*Pterocarpus marsupium*), African (Gambia) kino (*Pterocarpus erinaceus*), Bengal kino (*Butea* sp.), and Australian kino (*Eucalyptus* sp.).

Myrobalans are the dried fruits of a tree (*Terminalia chebula*) which grows in India.

Valonia is the cups of acorns (*Quercus ægilops*) from Asia Minor and Greece.

Divi divi, or cascalote, is the dried seed pod of a tree (*Cæsalpinia coriaria*) of tropical America. It comes chiefly from Venezuela. Algarobilla (*Cæsalpinia brevifolia*) of Chile is seldom exported.

Palmetto extract is made from the roots and creeping stems of the saw palmetto (*Serenoa serrulata*) in the southern United States and northern Mexico.

Canaigre roots (*Rumex* sp.) are collected in Texas and New Mexico and in Mexico, but are relatively unimportant.

**Galls.** Oak galls, or nutgalls, are the product of small insects allied to the wasps and belonging to the order *Hymenoptera*. These insects cause hard, woody abnormal growths upon the smaller branches and leaves of oak trees. The female deposits an egg within the bark, and when the tiny larva hatches, it feeds on the soft wood. The insect is supposed to secrete a stimulating fluid which augments the growth and causes the gall to form. When the larva attains its growth, it changes to the pupa and

then to the perfect fly and cuts its way out of the gall. The commercial oak galls grow upon a tree (*Quercus lusitanica* var. *infectoria*) common in southwestern Asia (the insect cause is *Cynips quercus tinctoriæ*). The best galls come from Syria and Asia Minor and are exported from Aleppo. Galls contain gallic acid, which is closely allied to tannic acid. They are used for tanning and especially for making ink and dyes with salts of iron. There are other commercial and useful galls growing upon trees (*Rhus semialata*) in China and Japan. These are caused by plant lice (*Schlechtendalia chinensis*), insects belonging to the suborder *Homoptera*. Pyrogallic acid, a chemical derived from galls, is an important photographic developer.

Many other tans are of local importance in various parts of the world.

# GUMS, RESINS, AND RELATED SUBSTANCES

Gums, resins, and the like are derived from the sap or juices of trees and plants. The word "gum" is very loosely applied and in popular speech designates almost any substance which seems to have a somewhat sticky feel or which forms a sticky solution. In this sense many substances are inaccurately called gums, such as resins, copals, rubber, camphor, lac, etc.

True gums are plant secretions which dissolve and form a mucilage with water. They are not soluble in alcohol. They are chiefly used in stiffening laces, silk, and cotton fabrics, in printing and dyeing calico, in making confectionery, cordials, mucilage, printer's ink, water colors, medicines, and in the manufacture of paper. Bordeaux, Trieste, London, and Hamburg are the chief centers for the wholesale trade in gums.

**Gum arabic.** Gum arabic is a soluble gum obtained from small thorny trees (*Acacia arabica*, *A. verek*, etc.). It comes from dry, sandy regions in Arabia and northern Africa. There are many gums which are nearly related and are considered identical or at least satisfactory substitutes. Among the most important of these are Kordofan gum, Sudan gum, Senegal gum, Sunt, Suakin gum, Morocco gum, East Indian gum, etc., the name denoting the locality.

Practically all these gums are from white to yellow or reddish in color. They often come in small lumps, balls, or "tears" up to half an inch or an inch in diameter. They are sorted according to size, color, and purity, and come on the market in different grades.

**Gum tragacanth.** Gum tragacanth swells up in cold water, forming a thick jelly. It dissolves in hot water. This gum is from thorny shrubs (*Astragalus* sp.) which grow in Persia,

Asia Minor, Syria, and adjacent regions. The best qualities (flake tragacanth) are in thin, flat pieces, dull white in color. Other varieties are known as lump tragacanth, Persian insoluble gum, sarcocolla, etc. The poorest gums of the tragacanth type are often called hog gum.

**Various tree gums.** Wattle gum from Australia and Cape gum from South Africa are from other species of acacia trees. They are similar in nature to gum arabic.

East India gum, or ghati gum (*Anogeissus* sp.), from India is more or less used as a substitute for gum arabic.

Cherry and other fruit trees produce gums that are marketed in limited amount.

Karaya gum (*Sterculia urens*) from British India has qualities similar to tragacanth.

Other gums of some slight commercial importance are mesquite, angico, cactus, kuteera, bassora, cashew, etc.

FIG. 35. Gum-Arabic Industry in Kordofan, Sudan

A native is tearing away a strip of bark loosened with his hatchet from an acacia tree. Drops of gum will ooze from this wound, and he will gather them after a few weeks. He wears on his right arm an amulet to protect him from wild animals and other dangers

**Dextrine.** Dextrine, or British gum, is made from starch by roasting or by treatment with dilute acid (commonly nitric acid). It is usually prepared from cornstarch (*Zea mays*) in the United States and from potato starch (*Solanum tuberosum*) in Europe. It is sold as a powder called white dextrine or

canary dextrine according to its color. Dextrine is an artificial gum with properties similar to gum arabic. It is useful for making mucilage, for stiffening cotton textiles, for thickening colors, for calico-printing, for giving a glaze to paper and cardboard, and for producing a "head," or foam, on beer and other beverages.

Other mucilaginous substances with properties more or less like the gums are seaweed gelatine, animal gelatines, and glues.

**Resins.** Resins are insoluble in water. Their most important use is in making varnish, for which purpose they are dissolved in turpentine or linseed oil or alcohol. The hardest resins known were formed hundreds of years ago and are dug from the earth, usually from a depth of not more than a few feet, in places where forests once grew.

**Amber.** Amber is the hardest of all the fossil resins. It is the product of an extinct tree (*Pinites succifer*). Most of the commercial supply comes from the shores of the Baltic Sea. It is carved into cigar holders, mouthpieces for pipes, beads, etc. Small fragments can be heated and pressed to form blocks (artificial amber). Amber is heated and distilled to render it soluble for making varnish. In distilling, amber oil is obtained. Amber is so scarce and costly that only very small quantities go into varnish.

Imitations of amber made from coal tar are much used for cigar holders and pipestems. The same substance (bakelite, a synthetic phenolic resin) is valuable for electrical insulation.

**Copals.** The hard resins are called copals and for making varnish must be melted or distilled before they will dissolve. The most costly of the copals are the hardest varieties and those which have the least color. The word "animé" is sometimes, but not always, used to mean the same as copal.

Zanzibar copal, gum animé or East African copal, is the hardest of this group. The tree (*Trachylobium hornemannianum*) grows in Zanzibar, Mozambique, and Madagascar. Some comes from living trees (tree copal, or "sandarusi-miti"). Another

variety (chakazzi, or jackass, copal) is dug from the ground but is of recent formation. The best or true "sandarusi" copal is a fossil resin which when dug from the ground is covered with a sandy-reddish opaque crust. This is removed usually by washing with a solution of soda or potash. After it is washed, the resin shows a peculiar bright pebbly surface called the goose skin, characteristic of the best grades of Zanzibar copal. Years ago the washing was done chiefly in Salem, Massachusetts, and in Bombay, India, whence came the names "Salem copal" and "Bombay copal."

West African copals are known mostly from their localities; as, Sierra Leone (flint or pebble copal), Gabun, Loango, Angola, Benguela, Accra, or Congo copal. Certain varieties are called muccocota gum or ocota cocota.

Kauri copal, or kauri gum, is obtained in New Zealand. A little (mostly soft gum of inferior quality) is taken from living trees (*Agathis* sp.) of the pine family. Nearly all this resin is dug from the ground, where it occurs at depths of from a few inches to ten feet. Much of it is in small pieces only an inch or two in diameter, although some lumps weighing a hundred pounds have been found. The fossil kauri occurs in what are practically peat bogs. Industrial development looking toward a very large use of this kauri peat for the recovery of the gum and by-products has begun.

Manila copal, almáciga, sometimes called white dammar, is a resin from a large Philippine tree (*Agathis alba*). Some of it is from living trees and some is dug from the ground near the base of the trees.

American copal, Brazilian copal, Demerara copal, Guiana gum, locust gum, jatoba resin, or courbaril copal, is mostly from large tropical trees (*Hymenæa courbaril*, etc.). This is one of the softest kinds of the hard varnish resins.

**Dammar.** Dammar, or gum dammar, is a hard varnish resin of many commercial varieties from various trees. It comes from southern India, Singapore (*Dammara* and *Hopea* sp.),

Sumatra (*Shorea* sp.), etc. Black dammar (*Canarium* sp.) is from the East Indies. One variety is called sal, or saul, resin.

**Various resins.** Mastic (*Pistacia lentiscus*) is from the shores of the Mediterranean. Cape mastic, Bombay mastic, and American mastic resemble it.

Sandarac, sandarach or sandrac (*Callitris* sp.), is from northwest Africa. Australian sandarac is closely related.

FIG. 36. Drying Gambier in Singapore

True gambier is an extract made by boiling the leaves of a shrub cultivated in the East. The decoction is boiled till it thickens and is then allowed to settle. The mushy sediment is cut into cubes about an inch across and dried on trays in the sun

Spruce gum is from the spruce trees (*Picea*) of New England and Canada. It is used as chewing-gum but is unimportant.

Grass tree gum, acaroid resin, gum accroides, blackboy gum, or Botany Bay gum, is from an Australian tree (*Xanthorrhœa* sp.). It is used in lacquers and as a source of picric acid.

Dragon's blood, or palm dragon's blood, a red resin (*Calamus* sp.), comes mostly from Sumatra and is used for varnish and medicine. Similar resins are from other trees in Sokotra, Borneo, Mexico, and West Indies.

Pontianak resin is obtained in purifying gutta-jelutong.

Paracoumaron resin, a coal-tar product, is useful in making varnish.

Guaiacum resin, guiac or gum guaiacum, is from the lignum-vitæ tree (*Guaiacum officinale*) of the West Indies. Its chief use is in medicine. It is mostly obtained by heating the wood.

FIG. 37. Cleaning Kauri Copal in New Zealand

The fossil resin is dug from peat swamps in northern New Zealand. When found it is covered with dirt and trash which hide the yellow glassy copal. The surface coating is scratched off and the resin classified in commercial grades according to size, color, and purity

**Rosin.** Rosin, pine resin or colophony, is a resin prepared by the distillation of crude turpentine (see Turpentine). It is the most common and cheapest of all the resins of commerce. It is less hard than most other substances of its class. The chief producers are the United States, France, Spain, and Russia. In the United States three grades are on the market: "virgin," "yellow dip," and "hard." Virgin rosin is made from the first turpentine that exudes after the tree is "boxed." It is of a

very light-yellow or amber color. The greater part of the crude turpentine furnishes yellow dip. Hard rosin is almost black in color and is made from the scrapings from the tree after the turpentine has become too hard to run.

Rosin is used in making soaps and varnishes and for sizing paper. Paint manufacturers use it in preparing Japan driers, which are metallic resinates. It is used by tinners and plumbers as a flux for solder, by founders for giving tenacity to their cores, by manufacturers of china in the preparation of enamels, for making medicinal plasters and sealing-wax, and for rubbing on violin bows. It is an ingredient of brewer's pitch for coating the inside of barrels. It is used in ship calking, as an adulterant of fats, waxes, and mineral oils, and for mixing with tallow to make common candles. Rosin is graded according to its color by such letters as WW (water-white), WG, N, M, K, etc.

Turpentine, rosin, tar, and pitch are known in American commerce as "naval stores," a term which is a survival from past years and which, while essentially out of date, is still widely used.

When rosin is heated in a retort, it is decomposed into certain gases, liquids, and pitch. The liquid distillate is chiefly rosin spirit and rosin oil, the former resembling oil of turpentine. These are used in making varnish and for "rosin grease," a lubricant.

Ester gum is prepared by treating rosin with glycerin under pressure. The result is a much harder resin, being insoluble in alcohol. It is used for varnish.

**Shellac.** Shellac is prepared from crude stick-lac, a resinous material found on the twigs of many trees (especially *Butea frondosa*, *Zizyphus jujuba*, and *Ficus religiosa*). This substance is caused by an insect (*Tachardia lacca*) belonging to the order of plant lice. The lac insect punctures the twigs for food and then secretes a large quantity of resinous substance, or stick-lac, as a sort of cocoon and protection for itself and young. The stick-lac is gathered in quantity from wild trees and those cultivated for the purpose. It is then worked and

washed free of useless matter. Red lac dye (extensively used before the use of anilines) is extracted by the washing. The dried and ground residue is known as seed-lac. Seed-lac is melted and poured out on broad leaves or on metal plates to harden. The thin sheets which result are called shellac, and the thick plates, or the drops, are called button-lac. Ordinary orange-colored shellac is bleached with hypochlorite of soda to make white shellac. Commercial grades are known as garnet, orange, white, and bleached. Shellac is dissolved in alcohol to make fine varnishes. Sealing-wax is prepared by mixing shellac with turpentine and various resins. Shellac is also used in putties, for sizing paper, for stiffening felt hats, etc. Dissolved in a strong solution of borax, shellac and dyes are used for drawing-inks and some water colors.

Gum resins are composed of a natural mixture of gum and resin with frequently some volatile oil. They are mainly fragrant substances used for medicine and incense.

**Myrrh.** Myrrh is a fragrant reddish gum resin obtained from large shrubs (*Commiphora* sp.) in northeastern Africa (Somaliland) and in Arabia. Indian bdellium and bisabol, or besabol, are similar.

**Frankincense.** Frankincense, olibanum or gum thus (*Boswellia* sp.), comes in yellow grains generally smaller than a pea. There are many similar substances sometimes used in place of it.

**Other gum resins.** Ammoniacum (*Dorema ammoniacum*) is from Persia and is used in medicine. Galbanum is from herbs (*Ferula* sp.) which grow in Persia. Opopanax is from southern Europe and is used in perfumery. Scammony, or scammonium, is prepared from roots (*Convolvulus scammonia*) from Aleppo and Smyrna and is used in medicine.

Asafetida (*Ferula* sp.) is from Persia, Afghanistan, and Turkestan. It is used in medicine and as a condiment.

Gamboge, or "gummi gutti," is obtained in Indo-China by tapping trees (*Garcinia* sp.) and collecting the yellow juice

in joints of bamboo, where it hardens. It is used in medicine, for coloring varnishes, and for making water colors.

**Oleoresins.** These are usually soft, sticky products consisting of a mixture of resin with volatile oil. Balsams are similar in general appearance but are different in chemical composition.

Crude turpentine, American turpentine, Strassburg turpentine, or Russian turpentine, is obtained by tapping several species of pine trees. It is a natural combination of resin with essential oil. Venice turpentine is from the European larch (*Larix europæa*). This soft grayish substance is sometimes called gum thus.

"Elemi" is a term applied to a variety of resinous products. Hard elemi sometimes means the softer varieties of copals, such as Brazilian copal. Elemi is applied more properly to soft oleoresins from various tropical countries.

Manila elemi, or brea resin, is from the pili tree (*Canarium luzonicum*) of the Philippines. It is of considerable local use for calking boats, making torches, etc., but is of little importance in export trade.

Benzoin, or gum benjamin (*Styrax benzoin*), is from Siam, Java, and Sumatra. It is used for incense and medicine. Labdanum (*Cistus creticus*) from Crete is used in perfumery and medicine. "Tacmahac" is a name given to an unimportant oleoresin, usually of uncertain origin, from tropical America. It is used medicinally.

Copaiba balsam, or copaiva (*Copaifera* sp.), comes from Venezuela (Angostura, Maracaibo) and Brazil (Pará and Bahia). Peruvian balsam (*Myroxylon pereiræ*) comes largely from Salvador. Its chief use is in medicine. Tolu balsam (*Myroxylon toluiferum*) is from northern South America.

Canada balsam, Canada turpentine or balsam of fir, is collected chiefly in Quebec from the balsam fir tree (*Abies balsamea*). It is used in medicine and as a cement, especially in microscopic work.

Storax, or styrax (*Liquidambar orientalis*), is an aromatic sticky balsam from Asia Minor. It is used in medicine and perfumery. American storax is from the sweet gum tree (*Liquidambar styraciflua*).

Extracts and inspissated saps are more or less resinous, or gummy, substances which often contain tannin, dyeing principles, or medicinal compounds. The important commercial products of this nature will be found under Dyestuffs or Tans or under Medicines, Stimulants, and Narcotics.

**Rubber.** Rubber, or caoutchouc, is an elastic substance produced usually from the milky juices of certain trees and vines which grow in tropical regions. Rubber milk is obtained by cutting the bark and catching the juice, or latex, as it flows out. It resembles cream in density and appearance and is composed essentially of globules of rubber floating in a watery liquid. This latex is found in tubes in the bark, not so deep as the cambium, or growing layer, where the sap flows. The rubber is separated from the milk by many processes which vary in different parts of the world with the different varieties of milk obtained from dozens of different trees and plants. Some kinds of latex contain little but good rubber; the milk of other trees carries a great deal of resin along with a little rubber.

**Wild rubber.** The best rubber of the world comes from the Pará rubber tree (*Hevea brasiliensis*), which grows wild in the Amazon Valley and is cultivated in the Far East. Native Brazilians collect the latex in cups after cutting the bark with small hatchets. They dry it on wooden paddles in the heat and smoke of a fire of burning palm nuts. As soon as a layer of rubber is properly "cured," more milk is poured on the paddle and another layer is formed, the process being continued until a ball, or "biscuit," weighing sometimes fifty pounds, is formed. This process gives "fine" Pará rubber. If the smoking is carelessly done and the ball of rubber is imperfectly dried, the quality is "entrefine." Some juice always dries on the trees or

in the cups, and this is known as scrap or sernamby. In Brazil all the rubber from this tree is called hule.

The Central American rubber tree (*Castilloa elastica*) grows wild in southern Mexico, Central America, and northern South America. A closely related tree (*C. ulei*) grows in the higher lands throughout the Amazon Valley. The rubber from castilloa trees is called caucho in Brazil and frequently comes in blocks or slabs. The name "hule" is applied to it in Mexico. The wild trees in Mexico and Central America are usually slashed with a machete from the roots up as high as a man can reach or sometimes as high as he can go with a ladder. The juice is caught in any convenient receptacle—a can, bucket, or even in a hole dug in the ground at the foot of the tree. It is coagulated by adding salt water, acids, or the juices of plants; by boiling; by diluting with water and creaming; by evaporation, sometimes in thin layers spread out on the broad surfaces of large leaves; or by some other crude method. In Brazil castilloa trees are almost always cut down and bled promptly along the whole length. It is stated that after tapping, a tree will be killed promptly by insects if it is left standing, and therefore it is wise to take the greatest possible yield of milk at once.

The Ceará rubber tree (*Manihot glaziovii*) grows in a drier climate than Hevea or Castilloa. It is native in northeastern Brazil. Wild trees are usually tapped on the roots and lower part of the trunk. The milk flows into a hole in the ground, and so this rubber is seldom clean. Better qualities, of course, come from the plantations. The rubber from this tree is generally known as maniçoba.

Scrap rubber is, in general, the juice which dries in the cuts or in stringy forms on the bark of a tree. It is often wound up in balls or lumps for convenient handling. There are some kinds of rubber milk which run or ooze slowly, with a flow not sufficient to fill even a small cup. This naturally forms nothing but scrap rubber. A great deal of maniçoba rubber is of this grade.

FIG. 38. Collecting Rubber Latex in Sumatra

Tapping has just commenced on a new plantation. With clean china cups and tin cans with covers, clean white milk is gathered. A little ammonia is added for preservation, and such latex is shipped in tanks to the United States for the manufacture of automobile cord tires

Vine rubber is chiefly from Africa and is the product of large vines (*Landolphia* sp., *Clitandra* sp., and *Cryptostegia* sp.), the main stems of which often grow to a diameter of three or four inches. There are many species of these creepers, a few of which give a plentiful flow of latex. Most of them, however, yield only a little juice from each cut in the bark, and so furnish something like scrap rubber usually done up in balls (niggers), rolls, or twists. In their effort to gather rubber in quantity the natives often tear the vines from the trees on which they grow and cut them into short pieces to get the milk. If there is a sufficient amount of latex, it is coagulated by heating or by the addition of the acid juice of plants. A little of this goes into sheet, or crêpe, rubber. Some of these rubber vines, especially those that live in the drier country, have underground stems and do not climb over the trees of the forest. These species seldom produce much juice; nevertheless they yield a considerable amount of commercial rubber. This "root rubber," or "grass rubber," is commonly obtained by the natives, who pull up the vines, which are sometimes a hundred feet in length. The stems, or "roots," are cut into short pieces and hammered with stones to loosen the bark, which is then boiled and pounded repeatedly until the woody portion is removed and the rubber seems fairly clean.

Mangabeira rubber is from a small Brazilian tree (*Hancornia speciosa*). It comes mostly from eastern Brazil.

Guayule rubber is from a shrub (*Parthenium argentatum*) which grows in the dry regions of northern Mexico. This plant does not have a milky juice. It is gathered and taken in bales to large factories, where it is ground up, the rubber being separated by mechanical or chemical means.

There are perhaps twenty other fairly important plants which yield rubber commercially, and a hundred or more different botanical species. Among these are the silk-rubber trees (*Funtumia*, or *Kickxia*) of central Africa and the Assam rubber tree (*Ficus elastica*), commonly grown as a house plant in the

United States. The total amount of rubber (in tons) coming annually from these trees is only a very small part of the world's supply. In fact, the Pará tree is by far the most important source, the castilloa and Ceará trees produce large amounts of rubber, and all the others are relatively unimportant.

**Cultivated rubber.** Many large plantations of Pará rubber trees (*Hevea*) have been established in Ceylon, India, Borneo, Sumatra, Java, the Straits Settlements, and other places in the Far East, and in central Africa. These furnish the bulk of the plantation rubber that now comes on the market.

Castilloa rubber is cultivated to some extent in Mexico, the West Indies, and southern India. The Ceará rubber tree is cultivated in eastern Brazil, East Africa, India, and Hawaii. The silk-rubber trees are cultivated in central Africa and to a small extent elsewhere. There are some plantations of Assam rubber trees in the Far East. Attempts have been made to cultivate the guayule shrub in Mexico but with small success up to the present time.

The planters of Ceylon were the first to give careful study to the best methods of tapping rubber trees and coagulating the latex. The aim on a plantation, of course, is to get the largest yield, not in one year but through a series of years, and so care is exercised to see that the cuts go far enough into the bark but not through it. By this means the latex tubes are cut, but the sap of the tree is not reached, and so the life of the tree is not actually impaired. The bark is renewed by natural growth in a year or two. A great variety of tools are on the market for the purpose of cutting, scratching, or pricking the bark in certain special ways. Much study has been given to such features as the best time for tapping, the shape and size of the cuts, the number of cuts for each tree, the interval of time between tappings, etc. The half-herringbone system of tapping is at present the one most widely used. Similar study has been given to the subject of coagulation. The cream is separated from the milk by several different methods: it may

be allowed to rise in broad shallow pans like those in an old-fashioned dairy; it may be run through a separator like milk in a creamery; or the latex may be coagulated by the addition of acetic, sulphuric, or hydrochloric acid, formalin, salt water, or some other fluid to curdle it. The separated cream is rolled and pressed, usually by machinery, to squeeze out the water, and then the sheets or biscuits of rubber are dried, sometimes with the help of smoke. According to the process used we get crêpe, smoked crêpe, sheet, biscuit, etc. Nearly all plantation rubber, whether from Pará trees or other trees, comes either in crêpe, sheet, or biscuit.

Plantation rubber now forms the bulk of the world's supply. Although wild rubber will probably continue to come on the market for many years, it seems certain that it will never again be a factor of first importance.

Recently American manufacturers have been importing liquid rubber latex from Hevea plantations in Sumatra. The milk is preserved by adding a small quantity of ammonia. It comes in tank steamers and is dried in this country by special machinery. Most of it goes into the manufacture of rubber tires, but some is added to paper pulp to make a special quality of paper.

The principal centers for the shipment of crude rubber are Singapore, Colombo, Penang, Pará, and Manáos.

Reclaimed rubber is a very important commercial article. It is obtained by tearing to pieces old rubber goods and separating the rubber from cotton, wool, metal, or other substances by mechanical and chemical processes. It is inferior to new rubber in most respects but serves very well indeed for making the cheaper line of rubber goods.

Artificial, or synthetic, rubber has been attempted by many skillful chemists and has been produced experimentally, but it is commercially of no importance. True rubber has certain qualities of strength and elasticity, but these words do not fully describe what men in the business call the "nerve" of

crude rubber, and there is much variation in different varieties of crude, due in part at least to the amount of resin it contains. Imitations of rubber or substitutes for it, termed factice, are generally lacking in strength and nerve.

The best substitute in general use is a cream-colored substance made by treating rape oil with chlorine. This is well known in a kind of eraser much used in recent years. Corn oil, castor oil, linseed oil, and cotton oil, heated with sulphur, form brown substances which are resilient and which for certain purposes are useful adulterants and substitutes for rubber. These substances are employed in very large quantities in manufacturing rubber goods. An article called mineral rubber is made by heating gilsonite with an asphaltic oil.

In its natural state rubber becomes soft and practically useless if it is fairly warm. To prevent this it is vulcanized, which means that it is mixed with a small percentage of sulphur and carefully heated. After this process it is more elastic, less soluble, and will stand more heat or cold without becoming either sticky or brittle.

Rubber bands, tire tubes, and other elastic articles are made of high-grade rubber with comparatively small percentages of other materials. The wearing surface of an automobile tire, on the other hand, needs to be made of something less elastic and more durable. It contains perhaps 40 per cent of rubber and 50 per cent of zinc oxide, clay, magnesia, or other substances. An automobile tire is elastic because of its inner tube of fairly pure rubber. It is durable, partly because of the composition of its "tread," or wearing surface, and partly because of the strength of the cotton canvas or cord with which the shoe is built up.

Hard rubber, vulcanite or ebonite, is vulcanized with as much as 35 per cent of sulphur, often with the addition of camphor and copal.

Rubber is colored black with lampblack, or red by vulcanizing with sulphide of antimony. In order to manufacture

articles having a wide range of uses and many different qualities, rubber is mixed or compounded with such things as litharge, whiting, clay, barytes, charcoal, asphaltum, cork, emery, powdered glass, pumice, powdered metals, graphite, pulverized coal, asbestos, magnesia, infusorial earth, lime, talc, etc. Rubber enters into the manufacture of almost innumerable substances, among which the following may be mentioned: soft or vulcanized rubber bands, threads for elastic cloth, toys, shoes, boots, tires, tubing, hose, cushions, belting, waterproof cloth, printing-rolls, stamps, stoppers, etc.; hard-rubber combs, brushes, handles, electrical instruments and other machinery, surgical and toilet appliances, buttons, and trays and vessels for holding corrosive chemicals. Rubber is used in grinding-wheels as a cement to hold the particles of the abrasive together; also in floor cloths, cements, and some varnishes.

**Gutta-percha.** Gutta-percha is similar to rubber. It is obtained from the milky juice of large trees (*Palaquium* sp.) which grow wild in Java, Borneo, the Malay Peninsula, and islands as far off as the Philippines. Singapore is the principal center of the trade in crude gutta. To gather it the trees are cut down by the savages who inhabit the forests. They ring the trees and catch the milk which runs from the cuts. The milk soon thickens and hardens and is then put into a pot of boiling water, where it becomes so soft that it can be kneaded and pressed into a compact mass. The crude commercial material is purified by being ground in hot water, by which process the chips, bark, and sand are removed. The plastic mass is then rolled into thin sheets or formed into threads and is rolled into balls and pressed. At ordinary temperatures gutta-percha is compact, pliant, tough, and but slightly elastic; at 194° F. it becomes plastic, so that it can be kneaded and brought into any desired shape, which it retains unaltered when brought back to the ordinary temperature. It is not nearly so sensitive to cold as rubber, not being altered by a temperature of 14° F.

No other plastic substance has so great an electrical resistance. Whether in the ground or in the water, gutta-percha retains this property unaltered. It is this property that gives gutta-percha its most important use, as an insulating material for electrical wires, especially for submarine and underground cables. Gutta-percha is especially useful for articles exposed to moisture, damp, cold, and acids. For this reason it is employed in the form of hose for conducting cold water, beer, wine, acids, and corrosive liquids. It is used by electrotypers for making molds; for making golf balls; for belts running in wet places; and for buckets, ladles, siphons, and spigots in chemical factories. Dentists use it for filling teeth.

There are several substances similar to gutta-percha obtained from the milky juices of trees in the East Indies. Gutta-jelutong (jelatong), or pontianak (*Dyera costulata*), is the most important. The natives coagulate it by the addition of kerosene, and make it into balls or blocks which resemble white cheese. It contains about 15 per cent of rubber and considerable resin. Deresinated pontianak is used by manufacturers in certain kinds of rubber goods. The resin is used in varnishes. Pontianak is used to some extent in chewing-gum.

Balata is from a large forest tree (*Mimusops*) of Guiana and northern Brazil. Its properties are much like those of gutta, and its chief use is for making belting for heavy machinery.

**Chicle.** Chicle, or crude chewing-gum, is obtained by boiling the milky juice of a tree (*Achras sapota*) that grows in Mexico and Central America. Yucatan produces almost the entire supply of chicle and exports nearly all of it to Canada and the United States. A large percentage of the chicle imported by the United States comes in through Canada, where it goes through a refining process. Some comes from Venezuela. For the preparation of chewing-gum the chicle is dried, washed, mixed with glucose, paraffin, or other materials, flavored, rolled out into thin sheets, and put up in small packages for sale.

# MISCELLANEOUS PRODUCTS

**Live animals.** There is considerable international commerce in live animals of many kinds. Cattle, sheep, pigs, chickens, green turtle (*Chelone mydas*), terrapin, lobsters, crabs, snails, and even fish are shipped long distances to be killed for food upon arriving at their destination.

Horses, mules, donkeys, and camels are dealt in as beasts of burden.

Cattle, horses, sheep, pigs, goats, camels, poultry (including ostriches), fish, bees, and various wild animals (especially the animals that are fur-bearing) are bought and sold for breeding purposes, for which the best individuals often bring high prices.

Dogs, cats, rabbits, ponies, canary birds, parrots, and other animals and birds are bred and sold as pets. Many of the best canaries come from the Tyrol, where they are bred in large numbers.

The by-products of slaughtering are very numerous, for in the great slaughterhouses no part of the animal is wasted.

**Horns and hoofs.** The horns and hoofs of cattle are utilized in making combs; buttons; umbrella, knife, and other handles; and fancy articles.

Waste scraps of horns, hoofs, hides, and dried blood are sometimes heated with scrap iron to make potassium ferrocyanide, an important chemical.

**Bones.** Bones are used in making buttons, combs, handles for toothbrushes, and other articles. Bone meal is an important fertilizer. The waste from bone manufacture is burned, forming bone charcoal or bone black, which is used in filters for oil and sugar and in making blacking. Some ammonia is recovered in the burning of bones.

**Dried blood.** Dried blood is used in purifying sugar, in clarifying wines, in dyeing, and in fertilizers. Blood albumen is employed in calico-printing and as a mordant in dyeing.

**Products from internal organs.** The intestines of cattle and swine supply goldbeater's skin, sausage skins, etc. Catgut, used for strings for musical instruments, tennis rackets, and surgical work, is nearly all prepared from the intestines of sheep. On account of their thinness and strength, bladders, cleaned and prepared, are used by druggists and oil dealers as coverings for vessels.

Pepsin, rennet, and other substances are prepared from the lining of the cow's stomach and certain other parts.

| | | |
|---|---|---|
| CATTLE | Milk | butter, cheese, casein, galalith, sugar of milk, ghee |
| | Skin | Sole leather, belting leather, etc.; splits, finished to imitate calf, alligator, etc.; rawhide; vellum; glue; gelatine; fertilizer |
| | Meat | fresh, dried, smoked, salted, corned, canned |
| | Fat | Tallow, oleo oil, stearin, stearic acid, neat's-foot oil, lubricating, leather-dressing, oleomargarine, butterine, cooking-fats, soap, candles |
| | Blood | purifying sugar, clarifying wine, dyeing, fertilizers |
| | Bone | Bone meal, bone grease, ammonia, soap, glue, size, bone black, buttons, handles, combs, fertilizers |
| | Horns and Hoofs | Combs, handles, buttons, cyanide of potash, fertilizers |
| | Tendons | gelatine, calf's-foot jelly, fertilizers |
| | Entrails | Sausage skins, goldbeater's skin, bladders, pepsin, rennet, glands, fertilizers |
| | Hair | brushes, felts, textiles, mortar, fertilizers |

**Gelatine.** Gelatine, glue, and size are essentially the same substance, the first name being applied to the best qualities. The purest gelatine is used for food. (Calf's-foot jelly is made by boiling calves' feet.) These substances are useful as adhesives, for dressing and stiffening cotton and silk fabrics or felt, for calico-printing and for sizing paper, for plaster, etc. Hides, sinews, feet, and horn pith are treated with lye and

boiled in water. This dissolves the gelatine, which sets on cooling. It is sold, according to its quality, under such names as "cabinetmaker's gelatine," "hatter's gelatine," etc.

**Glue.** Glue is usually made from bones by softening them with acid and then steaming them. Glue stock consists also of the trimmings of all kinds of hides (cattle, goat, sheep, deer, pig, and horse) as well as waste cuttings of rabbit and other skins from felt-hat factories. Liquid glues are kept in solution with weak acids. Fish glues are made from the heads, bones, and skins of certain fish.

**Isinglass.** Isinglass, a very pure gelatine used in confectionery, in clarifying wines and beer, and as an adhesive, consists of the cleaned and dried swimming-bladders of sturgeon and some other fishes. It is imitated in gelatine obtained from other sources. The name "isinglass" is incorrectly applied to the mineral substance mica on account of its similar appearance.

**Fertilizers.** Practically all kinds of slaughterhouse waste go into fertilizers. The question of what is a waste and what shall be used in fertilizer depends on the relative selling prices of different by-products and their cost of production.

Fish guano is the dried refuse of fish canneries. Sometimes it consists of the entire bodies of fish unfit for food. Whale guano is sometimes composed of almost the entire whale after the blubber is removed or it may be only the actual refuse parts.

Guano is used as a fertilizer. It is composed largely of phosphate of lime and is mostly the excrement which has accumulated as a result of the occupancy of dry islands by enormous flocks of sea birds. Some guano is also taken from caves inhabited by bats. Large deposits of guano occur on islands in the Pacific Ocean and in caves in the West Indies and Australia.

**Ivory.** Ivory is obtained chiefly from the tusks of the elephant (*Elephas*) in Africa and India. It is used for billiard balls, fancy carvings, knife handles, piano keys, combs, and formerly for vaccine points. Scraps and shavings are burned

to make ivory black for artist's paint. London, Antwerp, and Hamburg are the important wholesale markets for ivory.

Prime ivory consists of tusks (often called teeth) weighing at least twenty pounds. Smaller tusks are called scrivelloes. Those too small to cut into billiard balls are termed bagatellas.

Small amounts of ivory occasionally reach the market from the tusks of mammoths dug up or found in the ice in Siberia.

FIG. 39. Ivory Nuts, Esmeraldas, Ecuador

These hard palm nuts are shipped to Europe and North America for the manufacture of cheap buttons

The tusks, or teeth, of the walrus (*Trichechus*), the narwhal (*Monodon*), the hippopotamus, and the sperm whale (*Physeter*) are also sold as inferior kinds of ivory. Even bear's teeth are sometimes sold. Rhinoceros horns are often handled by dealers in ivory and are used for fancy articles.

Deer and goat horns, or antlers, are much used for knife handles. They come from India, Siam, China, Russia, Africa, and Canada.

Vegetable ivory, ivory nuts, corozo, or tagua, consists of the seeds, or nuts, of a palm tree (*Phytelephas macrocarpa*) native in Ecuador, Colombia, and Panama. When ripe and dry these nuts are hard and white, resembling ivory or bone. They are much used for making buttons, chessmen, and small ornaments. New York and Hamburg are the chief markets. Several other palm nuts are used in the same way, among them the African dum palm and the corozo (*Cœlococcus* sp.) of the South Sea islands.

**Pearl shells.** Pearl shells of the best quality are from the pearl oyster (*Meleagrina*). There are several species, known commercially as yellow-lip M.O.P. (mother-of-pearl), dark-lip M.O.P., white M.O.P., etc. They are gathered by divers along coral reefs in the South Pacific, along the coast of Ceylon, in the Red Sea, the Persian Gulf, the Gulf of Panama, and other places. The collecting is usually restricted by government regulations, which prohibit taking oysters smaller than a certain size and forbid repeated fishing in the same bed. Mother-of-pearl is used for buttons, knife handles, and fancy articles.

Fresh-water mussel shells (*Quadrula* and *Lampsilus*) are gathered in the rivers of the Mississippi Basin, especially in Illinois, Minnesota, Iowa, and Arkansas. These are known as Mississippi shells and are used like mother-of-pearl. They are actually much more important in the button industry than are the deep-sea pearl shells.

The abalone (*Haliotis*) shell comes principally from the shores of the Pacific and supplies a very brilliant mother-of-pearl.

Conch shells from the Bahamas and elsewhere are used for cutting cameos. Many other kinds of shells are on the market, including several varieties of snail, cowrie, etc.

Pearls suitable for jewelry are occasionally found in the true pearl oyster, the fresh-water mussel, and rarely in other shellfish.

There is a comparatively large manufacture of imitation pearls of many qualities. Some have been made by treating glass beads with "fish essence," a shiny, silvery preparation

of fish scales. The ablet, a small river fish, is said to have the best scales for the purpose, although sardine and herring scales have been used.

**Coral.** Coral for jewelry comes chiefly from the African shore of the Mediterranean. It varies from bright red to white. Common white corals are sometimes sold as curiosities.

**Cuttlebone.** The shell of the cuttlefish (*Sepia officinalis*) of the Mediterranean is heated, powdered, and used by jewelers and others for polishing. A piece is often hung in a bird's cage. The fish themselves are dried, and small quantities reach the United States.

**Tortoise shell.** Tortoise shell consists of plates from the back of the hawksbill turtle (*Chelone imbricata*). This animal is captured in tropical waters in many parts of the world. Shell comes from the Caribbean and Mediterranean seas, from the Indian Ocean, from the shores of Africa and South America, and from various Pacific islands. It is used for combs, for rims for spectacles, and for various fancy articles. Tortoise shell is imitated in celluloid.

**Sponges.** Sponges are the cleaned skeletons of peculiar animals (*Spongiæ*) that resemble plants and grow attached to rocks, shells, or corals in tropical waters. They are obtained commercially along the shores of the Mediterranean from Sicily and Algeria eastward to Syria. There are important fisheries on the coasts of the Bahamas, Haiti, Cuba, Florida, and the Philippines.

Sponges are taken either by dredging or by diving, and the business is carried on chiefly by Greeks, even in Florida waters. In life the sponge is covered with the soft gelatinous bodies of the animals. This material soon decomposes and is washed off. The sponges are bleached and finally washed in a weak solution of glycerin to prevent them from becoming brittle. They are classified as bath sponges, toilet sponges, sheep's-wool, silk, velvet, hardhead, cup, finger, etc., according to quality, shape, and size.

**Seeds, plants, flowers.** There is a large business in the production and sale of seeds, roots, bulbs, and young trees for the farmer and the gardener. Holland has an important export trade in flower bulbs.

Fresh flowers are raised in hothouses in Europe and America and in the open in the south of France. This industry in France is closely connected with the production of perfumes.

Everlasting flowers, immortelles or straw flowers, are various species (*Helichrysum* etc.) of flowers which grow wild and are cultivated in different parts of the world. They are dried and used for millinery and decoration.

**Teasels.** Teasels are the dried heads of a plant (*Dipsacus fullonum*) grown in Europe for use in finishing woolen fabrics.

**Insect flowers.** Insect powders, or pyrethrum, are the powdered flowers of certain species of chrysanthemum (*C. cinerariæfolium* etc.). They are cultivated for use in insect powders largely in Japan, Persia, and Dalmatia, to a small extent in North Africa, and in this country in California.

**Lycopodium.** Lycopodium powder consists of the minute spores of certain club mosses (*Lycopodium clavatum*) common in Europe. Russia is the chief producer. The powder is used in fireworks, by pharmacists, and in preparing fine castings.

**Soapbark.** Soapbark, or quillaia, from a tree (*Quillaja saponaria*) native to Chile, soapwort root (*Saponaria officinalis*) of Europe, and various other roots and barks form a lather with water. They are used for washing silks and delicate fabrics.

**Argols.** Argols, or lees, are deposited as a crystalline coating in casks of young wine. They consist of crude potassium acid tartrate ($C_4H_5O_6K$) and are the commercial source of tartaric acid and tartrates. This substance is produced chiefly in France and Portugal and is useful in making baking-powder, cream of tartar, tartar emetic, Rochelle salts, and as a mordant.

**Gourds.** Gourds from certain vines (*Cucurbita*), calabashes from a tree (*Crescentia*), and coconut shells are used locally for making bowls, dishes, and fancy articles.

# METALS AND THEIR COMPOUNDS

**Iron.** Iron is the most useful metal. It occurs in all parts of the world and in many minerals. The United States, France, Great Britain, Germany, Sweden, Spain, and Luxemburg are the greatest producers of iron ore, and important amounts are mined in Cuba, Chile, Poland, Austria, China, Algeria, Tunisia, India, Newfoundland, and Australia. The United States, Germany, Great Britain, and France are the great producers of iron and steel.

Four minerals, hematite, limonite, magnetite, and siderite, are found in sufficient abundance and contain enough iron to be used as ores. Rich deposits in many parts of the world are at present unworked because of lack of transportation, the distance from coal and limestone, cost of mining, or on account of such impurities in the ore as silica, phosphorus, or sulphur.

Hematite, the ore most commonly mined, supplies almost three fourths of the iron of commerce. It is found in immense beds in Minnesota and Michigan and is produced in large amounts in Alabama and other states. Abroad Germany, England, Spain, France, and Russia are the greatest producers. Ore of fine quality is mined in Elba and in Sweden. This ore, often called red hematite, is a sesquioxide of iron ($Fe_2O_3$) and is found in varieties ranging from crystallized to massive, from metallic to earthy in appearance, and from red to black in color. Different kinds are called specular iron ore, micaceous ore, red ocher, and clay ironstone.

Limonite, or brown hematite, is widely distributed. It is a hydrous oxide of iron ($2\ Fe_2O_3 \cdot 3\ H_2O$) and varies from yellow or brown to black in color and from submetallic to earthy in appearance.

Magnetite, or magnetic iron ore ($Fe_3O_4$), is a high-grade iron ore mined in New York and several other states as well as in Sweden and a few other countries. The total production is small compared with that of hematite or limonite.

Siderite, "blackband ore" or carbonate of iron ($FeCO_3$), is fairly important in England and in a few other localities.

FIG. 40. Iron Mine in Birmingham, Alabama

This is a hematite vein. The heavy red dust covers and smears everything it touches. Holes are bored with a pneumatic drill. The dip of the vein shows plainly as it parts from the roof, or "hanging wall"

Pig iron is made by smelting iron ore in a blast furnace. The ore, with carefully calculated proportions of limestone and fuel, is dumped in at the top, and the burning of the fuel is assisted by the admission of blasts of air around the bottom of the furnace. An intense heat is developed, and the furnaces are kept running night and day for long periods, usually until they need repairing. The limestone acts as a "flux," causing the ore to melt more easily than it otherwise would. Metallic iron and slag are formed and, while melted, run down to the

bottom of the furnace, whence they are drawn off, fresh ore, limestone, and fuel being frequently added. The slag, being lighter, floats on the molten iron and is drawn off separately; the iron runs into ditches and depressions in the sand floor, cooling in bars called pigs, which weigh about a hundred pounds each. At modern furnaces the pigs are cast in molds on a

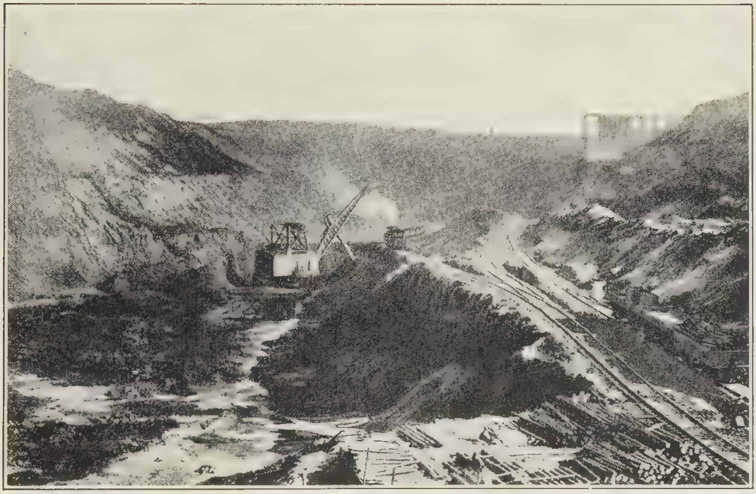


FIG. 41. Iron Mine at Mesaba, Minnesota

This great open pit shows some ocher-yellow color near the top, many shades of red (bright to dull) on the sides, and a color that is almost blue at the bottom. So much of the ore is earthy that a visitor may be excused for saying it is just red dirt

pig-machine, and not on a sand floor. The fuel used in smelting iron is usually coke. Relatively few blast furnaces are fired with coal or charcoal. Pennsylvania produces more than a third of the pig iron made in the United States, largely because of the fact that ore from the Lake Superior deposits can be cheaply transported to the neighborhood of the great coal fields and coke ovens of western Pennsylvania. Small amounts of iron are smelted direct from the ore in electric furnaces.

Slag is used for railroad ballast, in making certain kinds of cements, and in phosphatic fertilizers.

Cast iron is simply pig iron melted and molded in properly shaped sand molds. It is employed for making columns, stoves, large pipes, and parts of machines. It is more brittle and hence weaker than other forms of iron. It often contains 3 per cent or more of carbon.

Wrought iron is made from pig iron by melting the latter in a puddling furnace, where the impurities, such as carbon, sulphur, and phosphorus, are removed. Unlike cast iron, it can be altered in shape by hammering. It has much greater strength than cast iron, and is used for making bars, plates, wire, horseshoes, ornamental work, and parts of machinery.

**Steel.** Steel is used today for many purposes for which wrought and cast iron formerly served. Tin plate, for example, was for many years made on a base of wrought sheet iron, but is now sheet steel. Steel is made by the Bessemer, the open-hearth, the Siemens-Martin, and other processes. Much of the best tool steel is crucible steel, made by melting wrought iron in crucibles, with the addition of such substances as are needed to give it the proper chemical nature.

The chief merits of steel are its strength and hardness. It is used for rails, beams, structural material, machinery, tools, etc. Steel wire, wire rope, and sheet steel have a multitude of uses. Sheet steel coated with zinc is called galvanized iron. With a coating of tin it becomes tin plate, in ordinary speech usually called simply tin. Terneplate is coated with lead or a mixture of lead (75 per cent) and tin (25 per cent).

The qualities of steel, indicated by such words as "hardness," "strength," "toughness," "brittleness," and "elasticity," are influenced by its chemical composition and its physical condition. The manufacture of steel, therefore, is in the hands of chemists who control its chemical nature and of shopmen who bring it to the desired state by casting, rolling, forging, heating, cooling, etc.

Iron in cooling develops a crystalline structure a little like the granular structure of lump sugar or white marble. This

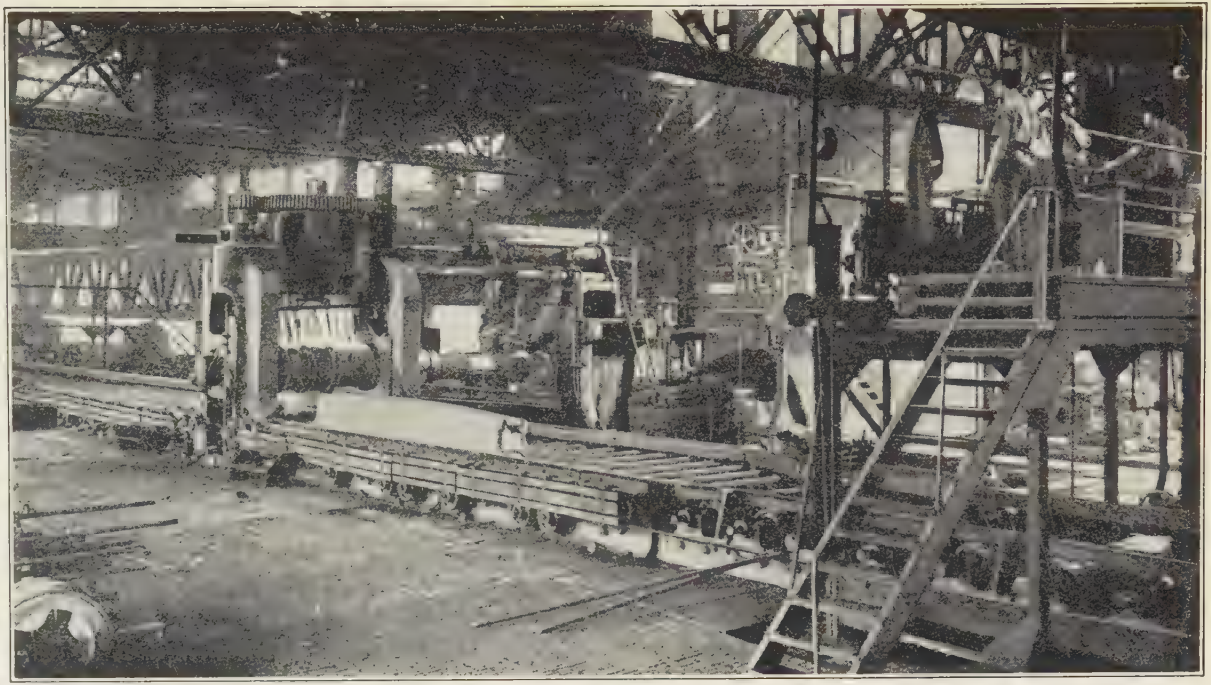


FIG. 42. Rolling Steel at Philadelphia, Pennsylvania

A white-hot ingot of steel is being formed into a structural shape in the great rolls on which a spray of water is falling. The men on the platform at the right control this powerful machinery

is seen plainly on a broken surface of cast iron. Steel also crystallizes in cooling, and many of its properties are dependent on the size, uniformity, and character of the crystallization. Ordinary steel is soft while it is red-hot. If it is cooled by dipping in ice water, it becomes very hard, but is at the same time rather brittle. If brought slowly to a certain temperature and then suddenly cooled, the steel develops a very fine structure, with no coarse crystals, and is both hard and tough. This process is called tempering.

Steel contains a small percentage of carbon, often as little as 2 per cent and sometimes only a small fraction of 1 per cent. This is a very important constituent, however, for it occurs in chemical combination with the iron, and very minute variations in the quantity of carbon are the direct cause of great differences in the hardness and strength of steel. Silicon, aluminum, and titanium give special qualities to steel. The presence of sulphur and phosphorus is usually objectionable. Manganese steel (containing from 12 to 15 per cent of manganese) has high tensile strength and resists wear. It is of value for railroad rails, burglar-proof safes, and parts for machinery.

There are numerous other elements which are added to steel to influence its qualities. Many of the special alloy steels, now developing a variety of important uses, are prepared in the electric furnace, where it is possible to get a higher heat than can be otherwise obtained. Nickel steel contains from 1 per cent to 35 per cent of nickel and is remarkable for toughness, tensile strength, and elasticity. Chrome steel is hard without being brittle. Steel with 2 per cent of chromium is used for armor-piercing projectiles. Chrome steels are used for chisels, ball-bearings, crushers, rolls, dies, tools, and machinery of special nature. Steel with a high chrome content (perhaps 20 per cent) is remarkable for its resistance to corrosion and rust. This is often called stainless steel. Alloy steels frequently contain both nickel and chromium or chromium and vanadium, the latter giving great strength to the metal.

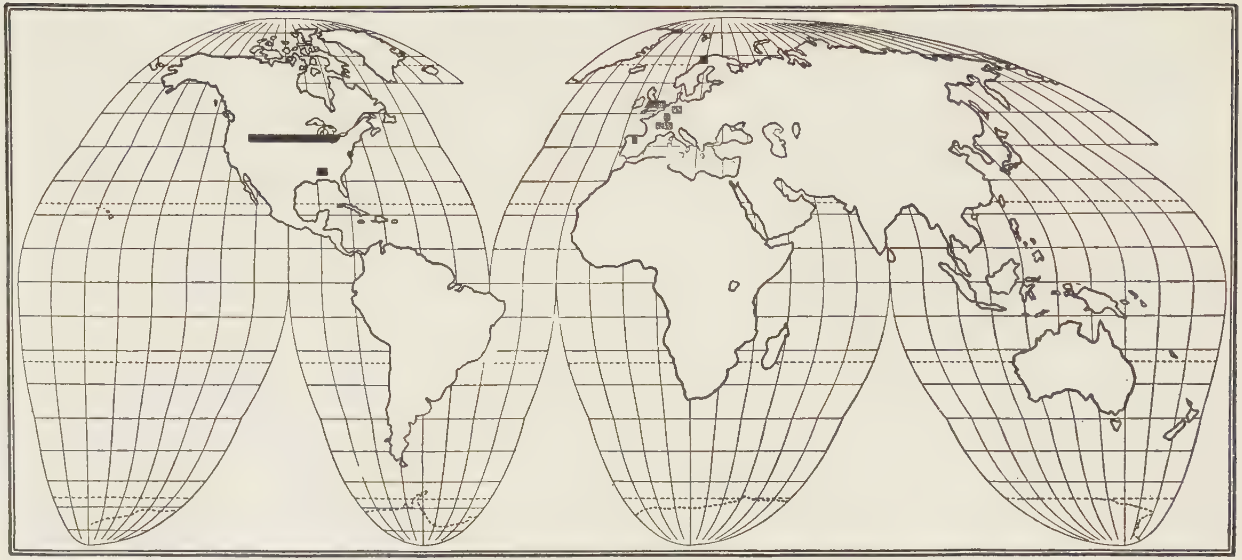



FIG. 43. Map showing Principal Sources by Countries of the World's Production of Iron

Length of bars represents percentages of entire production

High-speed steels retain their hardness when they become very hot, and are therefore of value for cutting-tools to be used under conditions when ordinary steel will lose its ability to cut. These steels contain tungsten (from 14 to 20 per cent) or molybdenum (from 6 to 12 per cent) and sometimes chromium also. The old Damascus steel contains tungsten and chromium, and this probably explains the wonderful quality of Damascus swords.

Steel wool (or shavings) is used as an abrasive, as is also "crushed steel."

**Compounds of iron.** The chemical compounds of iron are very numerous and have many uses. Red, brown, and yellow ochers are found in the earth. When ground up with linseed oil and mixed with turpentine they make paints. These ochers are oxides of iron, like hematite and limonite. Burnt ochers are made by roasting raw ochers, and give a considerable range of color. Ochers and other mineral paints are prepared by chemical processes, often from the by-products of other industries. Sienna and umber are similar to ochers but contain manganese. Rouge is a polishing-powder prepared from sulphate of iron. The dark varieties are termed crocus.

Prussian blue is an important dye containing iron. Copperas and other sulphates of iron are used in dyeing, in making ink, and for disinfecting. Crude acetate (pyrolignite) of iron, prepared from a product of wood distillation, is used in dyeing and in calico-printing.

Iron pyrite (sulphide of iron, $FeS_2$) is a common mineral. It is important as a source of sulphur.

**Manganese.** Manganese ores are mined in Russia, India, Brazil, and in smaller amount in many other countries. A little manganese is mined in Minnesota and other parts of the United States. Pyrolusite (oxide of manganese, $MnO_2$) and psilomelane are the common ores. They are used chiefly in the production of ferromanganese and spiegeleisen, preparations used in making steel. They are employed also in generating chlorine for use

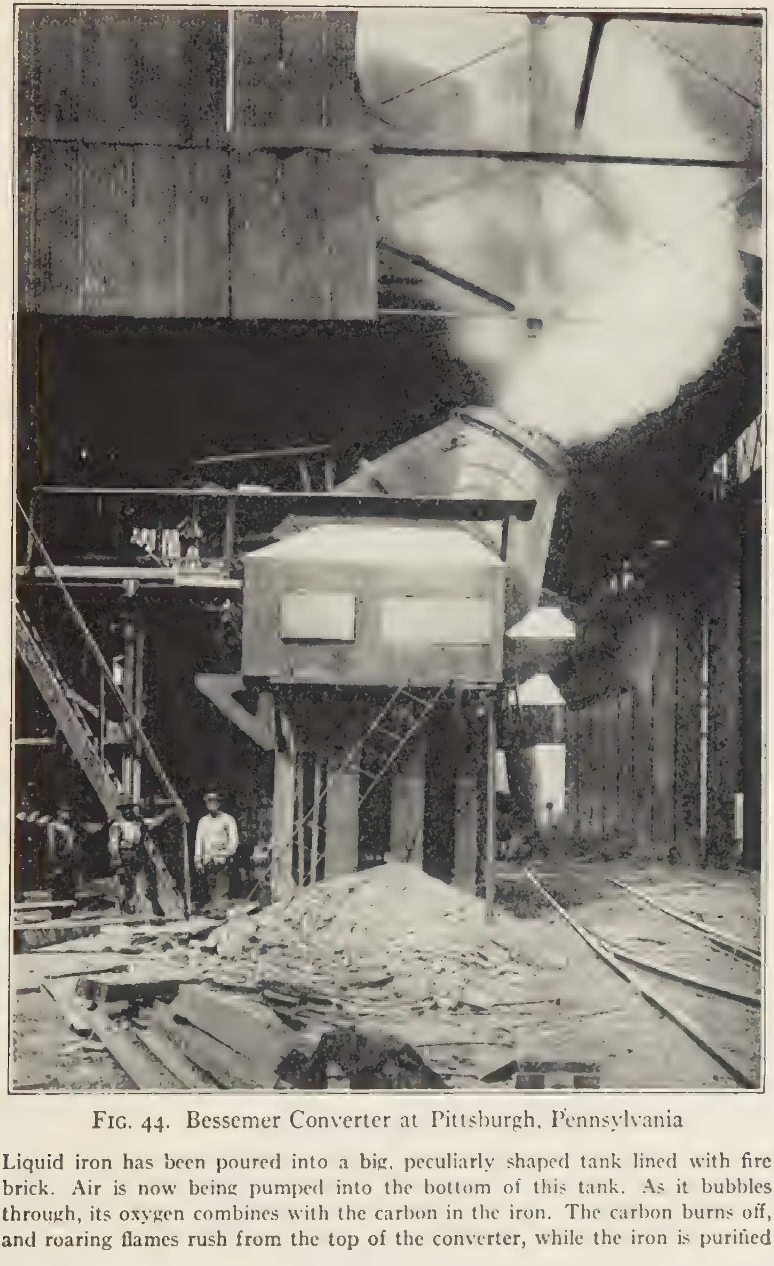


FIG. 44. Bessemer Converter at Pittsburgh, Pennsylvania

Liquid iron has been poured into a big, peculiarly shaped tank lined with fire brick. Air is now being pumped into the bottom of this tank. As it bubbles through, its oxygen combines with the carbon in the iron. The carbon burns off, and roaring flames rush from the top of the converter, while the iron is purified

in making bleaching-powders such as chloride of lime, in glass-making, and in the manufacture of oxygen.

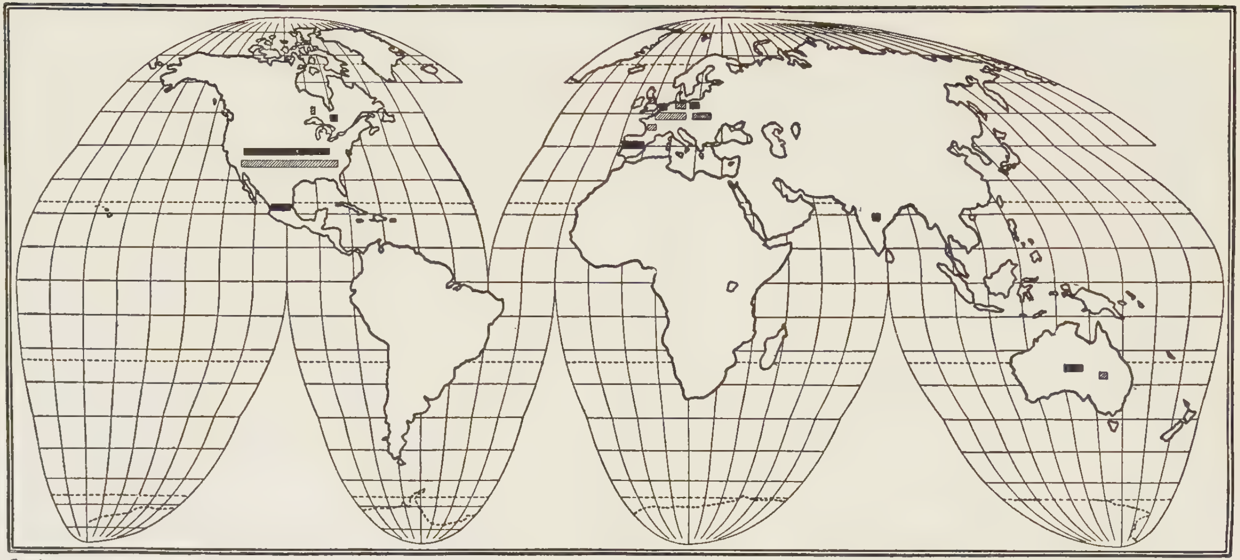
**Lead.** Lead is the softest, heaviest, and most malleable of the common metals, as well as one of the most easily melted. The United States, Mexico, Spain, Australia, Canada, Germany, and Belgium produce the most lead, but it is found in nearly all parts of the world. In this country the most important lead mines are in Missouri, Idaho, Utah, Oklahoma, Colorado, Montana, and Kansas. We import much lead bullion from Mexico.

Lead ores are often argentiferous, carrying so much silver as to be classed as silver ores. After smelting, the silver is extracted from the lead bullion. Galena (lead sulphide, $PbS$) is the only important ore of lead. It is a heavy lead-gray mineral with metallic luster. It often crystallizes in cubes, but the ore is generally granular-massive. Carbonates, sulphates, and other lead compounds are less common in nature.

Lead is used for making lead pipe, sheet lead, lead foil, and many alloys. Type metal is composed of lead and antimony. Solder contains lead and tin. Lead enters into pewter, Babbitt metal, and fusible metal. Sheet steel coated with lead or with lead and tin is called terneplate.

White lead is a basic carbonate of lead prepared in powdered form. Ground up with linseed oil and mixed with boiled oil and turpentine it makes the best white paint known. White lead is also employed in glazing earthenware. It is frequently mixed or adulterated with cheaper substances such as lead sulphate, barite, or chalk.

Red lead (lead oxide) is used as a pigment, in making flint glass, and in special cements. Litharge (another oxide) is used in preparing pigments, as a drier in making boiled linseed oil, and for other purposes. Orange mineral is another lead pigment. Chrome yellow (lead chromate) is used as a pigment and as a dye. Lead acetate (sugar of lead) is used in dyeing. Lead soap is used in pharmacy.



Goode's Homolosine Projection

FIG. 45. Map showing Principal Sources by Countries of the World's Production of Lead and Zinc

Solid bar indicates lead. Ruled bar indicates zinc. Length of bars represents percentages of entire production

**Zinc.** Zinc is mined chiefly in the United States, Belgium, Poland, Germany, France, and Australia. Zinc ores are mined in many parts of Europe and in smaller amounts throughout the world. In this country Oklahoma, Kansas, New Jersey, and Montana furnish the most zinc ore. Some is mined with silver in Colorado and some comes from other states.

Sphalerite, or blende (zinc sulphide, ZnS), called jack by miners, is the important ore of zinc. It is black, brown, or red in color, and often breaks with a bright cleavage. This mineral frequently occurs with ores of lead. Carbonates, silicates, (calamine), and oxides of zinc are found.

The crude metal called spelter is obtained by distilling the roasted ore, or from the mixture of various metals in the "matte" from smelters.

Zinc is used in electric batteries, in making hydrogen, in the cyanide process for the recovery of gold, and in making etched plates for printing. Sheet zinc finds various industrial applications. Galvanized iron is made by dipping sheet steel in melted zinc, the thin zinc coating preventing the rusting of the iron.

Brass is an alloy of copper with zinc. German silver contains zinc, copper, and nickel, and zinc enters into various other alloys, including some kinds of solder.

Zinc oxide, or zinc white, is an important pigment. It has less covering power than white lead and is less expensive. It is mixed in rubber in the manufacture of tires and of many other articles. Zinc sulphate is employed as a pigment, in dyeing, and as a disinfectant. Zinc chloride is used as a wood preservative.

**Copper.** From an economic standpoint copper is one of the most important metals. The United States is the greatest producer. The greater part of its output is from mines in Arizona, Montana, Utah, and Michigan. Large amounts are produced in Chile and in Katanga in the southern part of Belgian Congo. Copper is produced in smaller quantities in

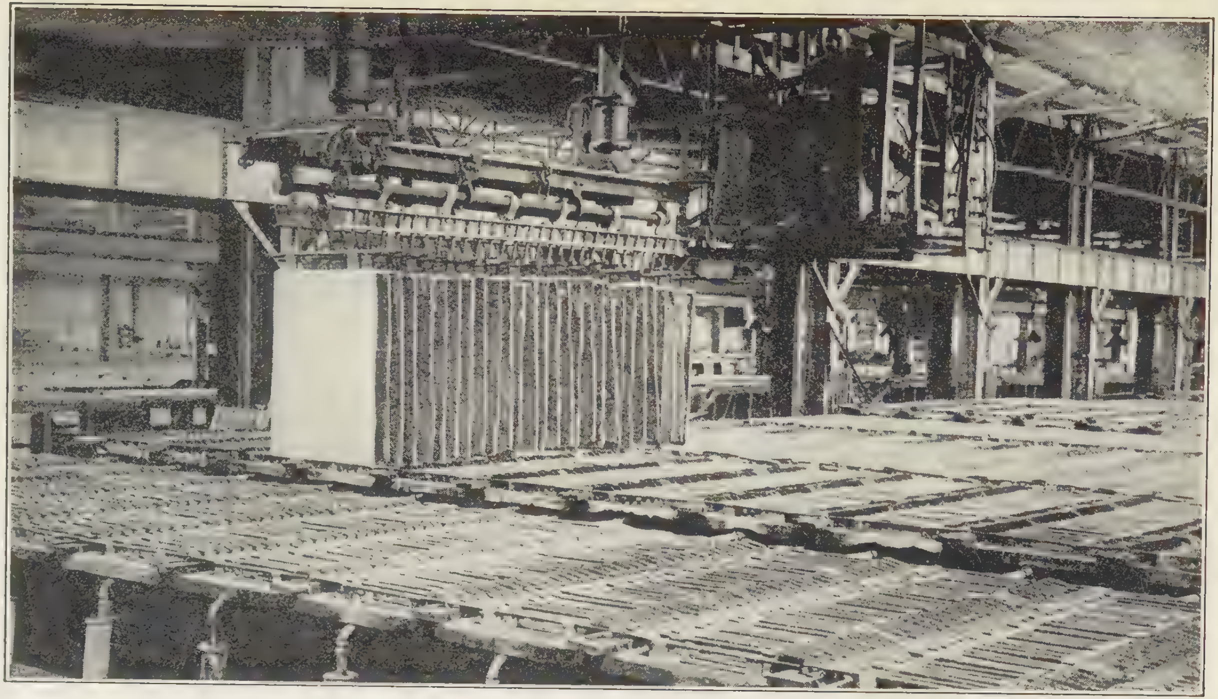


FIG. 46. Electrolytic Copper at Perth Amboy, New Jersey

The crane holds sheets of pure copper from the tanks below. The copper has been deposited on the cathodes by the action of a weak electric current. Impure copper is placed at the anodes, and an electrolyte (solution) is circulated through the tanks

Japan, Spain, Canada, Mexico, Peru, Australia, Germany, and many other parts of the world.

Copper ores vary widely in composition and occurrence. Native copper in metallic particles mixed with rock is the principal ore at the Lake Superior mines. Chalcopyrite and bornite (sulphides of copper and iron) are found in many parts of the world. Chalcocite (copper sulphide) is an important ore in Montana. Malachite and azurite (green and blue carbonates of copper) are common ores in Arizona. Copper oxides and copper silicate are also found. These ores are of many colors and often occur associated with or carrying other metals, such as gold, silver, lead, and zinc. After concentration the ores are usually roasted and smelted, and the resultant "copper matte" is separated by refiners into the various metals which it contains. Electrolytic processes of refining are largely employed.

The demand for copper has increased enormously in recent years, owing to its use in electrical work, where it is employed in the form of copper wire. Copper is used also for making coins, pipes, kettles, cartridge shells, rivets, plates for printing and engraving, for plating ships, and for roofing and plumbing. Compounds of copper also furnish blue and green dyes and pigments.

Brass is an alloy of copper and zinc. Bronze contains copper and tin, sometimes with the addition of zinc. Phosphor bronze, aluminum bronze, statuary bronze, bell metal, gun metal, and Britannia metal are other alloys containing copper.

Blue vitriol, bluestone or copper sulphate, is the most important of the numerous chemical compounds which contain copper. It is used in the preparation of electrolytic baths, in dyes, in pigments, in silver-refining, and also as an antiseptic. Large quantities are used in spraying plants.

**Gold.** Gold is found in nearly all parts of the world. The United States, South Africa, Canada, and Australia contain the richest gold fields known. In this country California, Colorado,

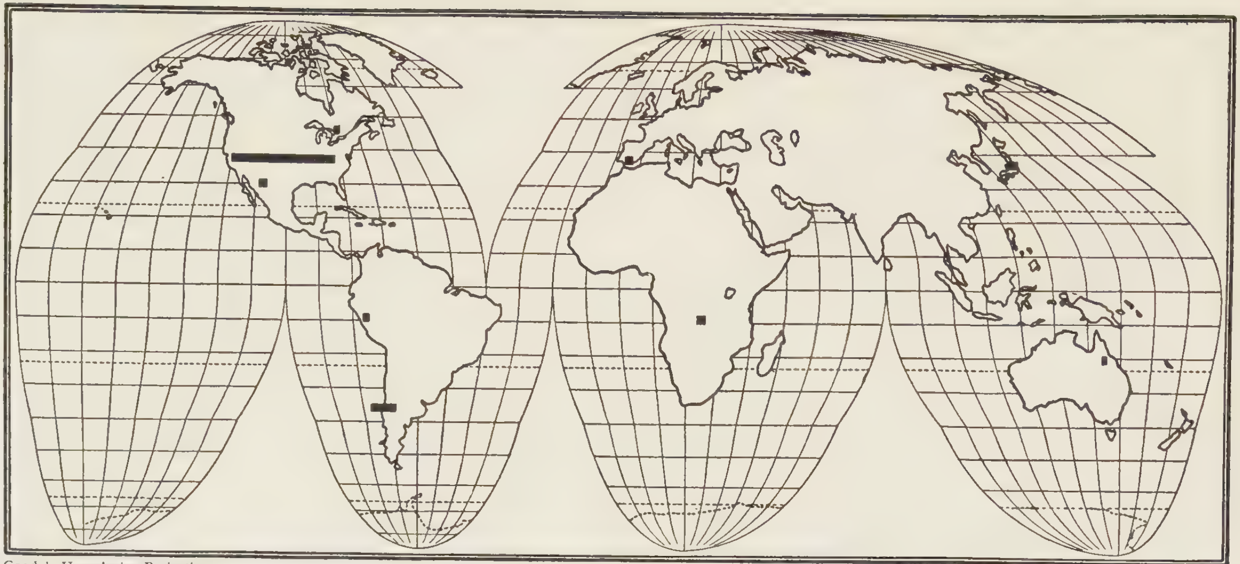



FIG. 47. Map showing Principal Sources by Countries of the World's Production of Copper

Length of bars represents percentages of entire production

Alaska, Arizona, and South Dakota are the largest producers. Gold is usually found in minute particles disseminated through rocks or sands. When in rock it is ordinarily found in veins of quartz, often associated with pyrite or other sulphides. Tellurides of gold are mined in Colorado and Transylvania.

Placer deposits consist of beds of sand or gravel derived from the wearing away of rocks, and contain gold in grains and nuggets. Some placers are extremely rich, and from them the metal is obtained by washing. The crudest method is by rocking a small quantity of the gravel in a basin of water: the particles of gold, being heavy, sink to the bottom and are easily collected. On a larger scale, gold-bearing gravels are washed by a current of water through sluices, or long wooden gutters. The gold is caught by strips of wood ("riffles") fastened diagonally in the bottom of the sluice.

Where there is abundant water, banks of gravel are sometimes washed down by strong jets directed on the bank through nozzles, and the gravel is carried by the water through sluices. This is termed hydraulic mining.

Rocks that contain gold are broken and then crushed to a fine pulp with water in stamp mills. The pulp is passed over copper plates covered with mercury, which catches and forms an amalgam with the particles of gold. Usually after the pulp passes the plates it goes to concentrating-machines which separate the heavy part from the lighter, and the heavy concentrates are treated by smelting, by chlorination, or by the cyanide process to recover gold that was not caught by amalgamation. Gold is soluble in a solution of cyanide of potassium and may be recovered from the solution by treatment with zinc. This process is successful with ores that contain comparatively little gold, and has made possible the profitable working of such deposits as those in South Africa.

When an ore is pulverized, some of the rock goes to a very fine powder which forms a soft, smooth mud (slimes) containing very minute particles of metal. This is often treated

by the "flotation" process, which consists in running it through a bath of bubbling oil, often an essential oil like eucalyptus or some petroleum product. It is a curious and important fact that the bubbles in such a light oil catch and carry aside any metallic particles which they happen to touch. The process is applied not only to gold but also to sulphide ores of copper etc.

Gold is used chiefly for jewelry and currency. It is valued on account of its rarity, its beauty, and because of the fact that it does not readily tarnish and is not attacked by ordinary acids. It is almost always alloyed with copper or with copper and silver. United States gold coin contains 9 parts of gold to 1 part of copper. Pure gold is said to be 24 carats fine, and the best ordinarily used is about 18 carats fine. Gold is used also for making gold leaf for gilding, and in dentistry. Chloride of gold is used in photography.

**Platinum.** Platinum is a rare metal sometimes found with gold in placer washings, usually in grains. Before the World War Russia produced over 90 per cent of the world's supply, but since then Colombia has taken the lead. There are small amounts of platinum in Australia, Papua (New Guinea), Japan, and Canada; in the United States it is found in California, Oregon, Wyoming, and several other states.

Platinum is used in electrical work, especially in magnetos and in fine wires in incandescent electric lamps to support the filament. In chemical work it is used for crucibles and other apparatus and as a catalyzer in preparing sulphuric acid. It is employed in the construction of pyrometers and various other scientific instruments. It is also used by jewelers and dentists and in photography.

Associated with this metal is another rarer one, iridium, which is employed for the points of gold pens. Osmiridium (chiefly from Tasmania) is similar. Osmium and palladium are allied rare metals.

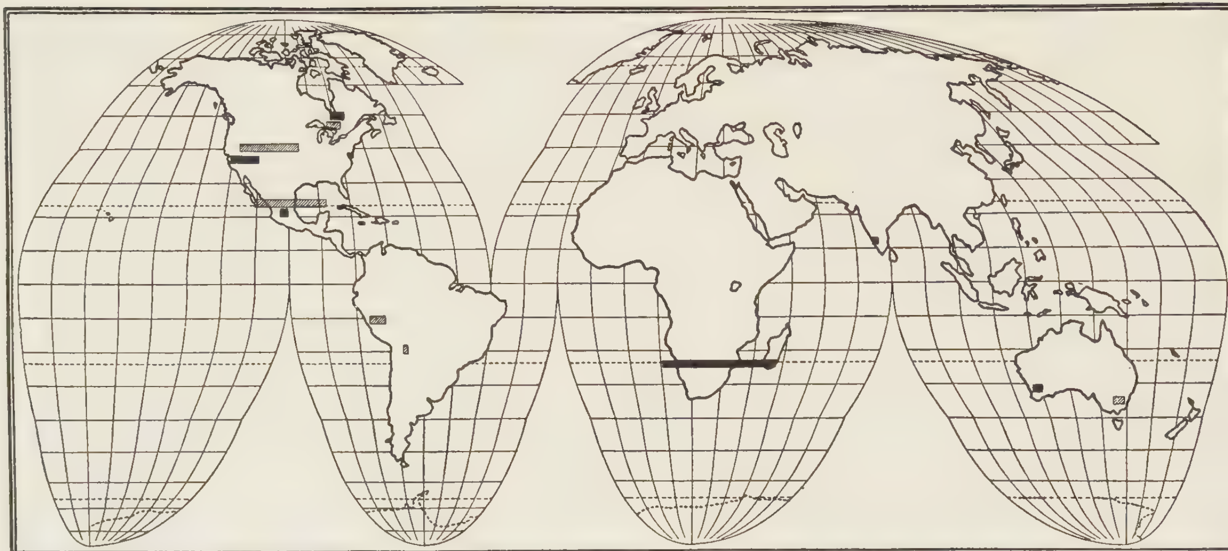
**Silver.** Silver is mined throughout the Rocky Mountain and Andes regions of America, in Australia, and to a small extent

in many other parts of the world. In this country Utah, Montana, Nevada, Idaho, and Arizona are the greatest producing states. Mexico and the United States are the chief producers of silver; other important producers are Canada, Peru, Australasia, Bolivia, Chile, Germany, Japan, and Burma.

Argentiferous galena is the most common ore and the source of a very large percentage of the silver produced in the world. The amount of silver carried by this sulphide of lead varies greatly, but a very few ounces of silver in a ton of ore make it profitable to work many deposits of lead which could not otherwise be mined. Ores of zinc and copper, occurring separately or associated with ores of lead and other metals, frequently carry silver. Almost all gold is found alloyed with a small percentage of silver. Pure silver occurs in small amount. Most of the silver compounds in nature are sulphides, such as argentite, pyrargyrite, stephanite, and polybasite, usually containing silver with arsenic or antimony. Chlorides and bromides (cerargyrite and bromyrite) are common ores in some parts of Mexico, the western United States, and Australia.

Silver is extracted from ores by smelting and by refining the resultant mixture of metals, by amalgamation with mercury, or by various other processes. It is made into useful and ornamental articles for the household and personal adornment, many of which are formed of some other metal or alloy covered with a plating of silver deposited by the aid of an electric current from a solution of cyanide of silver and potassium. The tarnish often seen on silver is due to its union with sulphur absorbed from gases formed by burning coal.

Solid silver articles, including coins, are almost never made of the pure metal but are alloyed with copper to harden them. Mirrors are made by coating one side of the glass with silver from a solution. Silver chloride and silver nitrate are used in photography. This use of silver for the emulsion on photographic plates, films, and paper consumes an enormous amount of the metal annually.



Goode's Homolosine Projection

FIG. 48. Map showing Principal Sources by Countries of the World's Production of Gold and Silver

Solid bar indicates gold. Ruled bar indicates silver. Length of bars represents percentages of entire production

The mixture of various cheap metals forms alloys such as pewter and white metal, which resemble silver in color and luster.

**Mercury.** Mercury, or quicksilver, is found in Italy, Spain, the United States, and various other countries. The mercury obtained in the United States comes from California and Texas.

Mercury is obtained from cinnabar (red sulphide of mercury, $HgS$). It occasionally occurs in a pure metallic state and in a few rare compounds. It is extracted by heating (distilling) the ore. The mercury, which volatilizes readily, is condensed as the gases are cooled after passing from the furnace. Mercury is peculiar in being a heavy metal which is liquid at ordinary temperatures. It solidifies at 38° below zero F. and boils at 675° F., a lower temperature than the boiling-point of any other common metal.

Mercury is used in the extraction of gold and silver by amalgamation. It is also used in silvering mirrors and for thermometers and barometers. It is employed in mercury-vapor lamps and electric storage batteries. Amalgams of mercury with other metals are used for filling teeth and for other purposes.

Vermilion is artificially prepared cinnabar, and is used as a pigment, as are other compounds of mercury. Calomel and corrosive sublimate (chlorides of mercury) are used in medicine. Mercuric nitrate is used for treating ("carroting") fur in the manufacture of felt hats. Other compounds are used in antifouling marine paint. Certain mercury compounds called fulminates are dangerous explosives.

**Aluminium.** Aluminium, or aluminum, is a metal that has been successfully refined for commercial use only within comparatively recent years. It is lighter than any other metal in common use and is very strong in proportion to its weight. It is readily ductile, does not easily tarnish, and is a remarkably good conductor of electricity.

One of its most important uses is as an addition to iron and steel, preventing bubbles and waste in castings. It is extensively employed as an electric conductor. This metal is of

growing importance, owing to its lightness and strength, in the construction of certain kinds of machinery. It is employed in airplane motors and in the framework for airplanes and dirigibles, for boat hulls and plating, for cooking-utensils, combs, lithographic plates, etc. Aluminum foil is used like tin foil, for wrapping candy, tobacco, etc. Powdered aluminum mixed with powdered iron oxide is called thermite. This material burns rapidly, generating a very high temperature, and is useful for welding metals. Powdered aluminum foil (aluminum bronze) is used in paints, printing, and explosives. Alloys of aluminum with copper, magnesium, and other metals, forming aluminum bronzes, are important.

Aluminum occurs very abundantly in the crust of the earth and forms numerous useful compounds. Corundum, feldspar, and clay contain large percentages of aluminum but are not suitable for use as ores of the metal.

Bauxite (aluminium hydrate, $Al_2O_3 \cdot 2\,H_2O$) is the ore from which aluminum is extracted and the only mineral from which it is now obtained commercially. It is a clay of peculiar composition, being a hydrate, whereas most clays are silicates. This ore is mined in only a few places in the world. In the United States it occurs in Arkansas, Georgia, Alabama, and Tennessee, and in Europe in France, Jugoslavia, Italy, Germany, Hungary, Austria, Spain, and Ireland. Important deposits have been opened in Guiana and India.

In refining aluminum, calcined bauxite is decomposed by a strong electric current. In the United States the electric power is generated at Niagara Falls and in Tennessee and North Carolina, where great hydroelectric plants are located. France, Germany, Norway, Switzerland, Great Britain, and Italy are also producers. Bauxite is also used as a source of aluminum in certain electric processes for making artificial abrasives and in chemical manufacture as a base for alum and other salts. Refractory bricks made in part of bauxite are of use in some metallurgical processes.

**Compounds of aluminum.** Cryolite, or kryolith (fluoride of aluminium and sodium, $3\,NaF \cdot AlF_3$), is a white mineral that is mined only in Greenland. It was formerly used as an ore of aluminum. At present it is of value in chemical manufacture as a source of fluorides and other salts, such as carbonate of soda, soda ash, alum, alumina, etc.

Alum is made by various processes from minerals, such as cryolite and alunite, and from clays. Chemically it is a sulphate of aluminium and potassium ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\,H_2O$). It is used in tanning leather, as a mordant in dyeing, and in printing, in baking-powders, in medicine, in sizing paper, in stucco-work for hardening plaster, in photography, in rendering wood and fabrics fireproof, in carbonizing wool, in bleaching, etc.

**Tin.** Tin is not found in paying quantities in the United States. Mines in the Malay Peninsula and on the neighboring islands of Banka and Billiton produce half the world's supply of this metal. It is obtained in Bolivia, Nigeria, China, Siam, Australia, and in Cornwall, England (in ancient times the only source of tin). It occurs also in Mexico, Chile, Peru, South Africa, and in the United States in Alaska, South Dakota, New Mexico, and a few other states, but not all these deposits are actually producing.

The only important ore of tin is cassiterite (tin oxide, $SnO_2$). It sometimes occurs in narrow veins through granite rocks, but is usually found as "stream tin" in small particles or pebbles in deposits of gravel, from which it is separated by washing. It melts at a comparatively low temperature and is easily refined.

Because tin is not acted upon readily by weak acids or by vegetable or animal juices, and because it resists oxidation under ordinary conditions, it is used extensively as a protective coating on steel. In making tin plate sheet steel is thoroughly cleaned by acid baths and is then dipped in a bath of molten tin. A layer of palm oil, zinc chloride, or other material covers the melted tin to prevent contact with the air. A thin layer of tin sticks to the steel, which is passed through rollers to squeeze

off superfluous metal and perfect the coating. Tin plate is used for cans for oil, fruit, vegetables, fish, etc., and for kitchen utensils. Very large quantities are used by petroleum refiners and by canneries in general. Terneplate, or roofing tin, is sheet steel coated with 25 per cent of tin and 75 per cent of lead. Tin foil is made by coating sheet lead with tin and then beating it into thin sheets.

Tin is sometimes used for pipes and other articles of block tin. Bronze and gun metal contain copper and tin; pewter contains tin and lead. Solder, type metal, white metal, Britannia metal, and anti-friction metals all contain tin.

Tin chlorides and other salts are used as mordants in dyeing, and some compounds are used in coloring glass and porcelain. Bichloride of tin is used especially for "loading," "weighting," silk fabrics. Dioxide of tin (putty powder) is used for polishing.

**Antimony.** China is by far the chief producer of antimony ore, although smaller amounts are mined in Mexico, Bolivia, Algeria, France, Italy, Turkey in Asia, Australia, and other countries. In the United States there are deposits in Nevada, California, and Idaho.

The chief ore is stibnite (antimony sulphide, $Sb_2S_3$), a lead-gray mineral. Considerable amounts are also obtained from antimony oxides and from ores of lead that carry antimony.

Antimony enters into many useful alloys. Anti-friction metals, such as white metal and Babbitt metal, consist of antimony and tin with small quantities of lead, copper, zinc, bismuth, and nickel. Type metal contains lead and antimony, often with a little tin and bismuth; Britannia metal contains tin, antimony, and copper; pewter sometimes contains antimony in addition to tin and lead.

Tartar emetic (antimony potassium tartrate) is used in medicine. It and other salts of antimony are used as mordants in dyeing. A sulphide of antimony is used for vulcanizing red rubber, and another compound forms a brilliant red pigment called antimony cinnabar. Other salts of antimony are used

for pigments, in glass manufacture, for fireworks, matches, and other industrial purposes. The natural black sulphide of antimony has been used for ages in the East as a powder for darkening the eyebrows.

**Arsenic.** Arsenic occurs widely distributed in the world, but in only a few places in sufficient quantity to be of commercial value. The United States, Canada, England, France, Germany, Japan, and Australia are the principal producing countries. It is often a by-product from smelting arsenical ores of copper, silver, etc. It is derived directly from arsenopyrite (arsenical iron sulphide) and from orpiment and realgar (sulphides of arsenic). Shot is often made of lead alloyed with arsenic.

Arsenic, white arsenic or arsenious acid, is an oxide of arsenic used for preserving skins, for making "sheep dip" (to kill insects that harm the sheep) and rat poison, as a mordant in dyeing, in making fine grades of glassware and enamels, and in making various other arsenic compounds. Paris green, one of the most important arsenic salts, is used for killing the potato beetle and other insects injurious to vegetation, and to a small extent as a pigment. Other compounds of arsenic are used as pigments and dyes, for medicinal purposes, and in making embalming fluid. Arsenic salts are used in preparing certain of the coal-tar colors.

**Magnesium.** Magnesium occurs in many limestone rocks in almost all parts of the world and is found in a variety of minerals. In the metallic state it burns readily and is used chiefly by photographers, either in the form of magnesium ribbon or in flash powders, to produce a brilliant light, and in the same way for star shells, tracer bullets, etc. for war purposes.

Its principal natural compounds are chlorides and sulphates, found at Stassfurt, Germany; magnesium carbonate (magnesite), obtained chiefly in Greece, Austria, India, and in California in this country; magnesium calcium carbonate (dolomite); hydrous magnesium silicates: talc (soapstone), serpentine, asbestos, and meerschaum. The metal is reduced from the chlorides.

**Bismuth.** Bismuth is found in Bolivia, Australia, Japan, China, Germany, and Spain and in smaller quantities in some other countries. It is a rare metal with a low melting-point. It is used in fusible metal alloys. These fusible metals usually contain bismuth with lead, tin, and cadmium. They are used for safety plugs for electric wiring, steam boilers, and automatic fire extinguishers. Bismuth compounds are used in medicine, pharmacy, and in coloring porcelain and glass. Type metal and anti-friction metals usually contain some bismuth.

**Cadmium.** Cadmium is a rather rare metal that often occurs in small amount with zinc ores. It is a by-product of zinc refineries and is produced chiefly in the United States and Upper Silesia. It is used as an alloy in fusible metals, for automatic fire extinguishers, etc., and in dental amalgams. Artists use a pigment called cadmium yellow. Cadmium compounds in small amounts are employed in dyeing, photography, medicine, and electrical work.

**Nickel.** Nickel is mined principally in the province of Ontario, Canada, and in the island of New Caledonia. Small quantities are found in Greece, Norway, Borneo, Cuba, South Africa, the United States, and elsewhere.

Garnierite, a green mineral (a hydrous silicate of nickel and magnesium), is the most common ore. It is exported from New Caledonia and is refined chiefly in France and Germany. Other compounds of nickel, such as arsenides and sulphides, occur. All these ores are generally associated with serpentine and chrome. The Canadian ore is magnetic iron pyrites (pyrrhotite, $Fe_{11}S_{12}$), which carries from 3 to 8 per cent of nickel.

Nickel is used for electroplating, for storage batteries, as a catalyzer in hardening cotton and other oils, and in certain pigments.

If steel contains a small percentage of nickel, its hardness and toughness are greatly increased. Nickel steel is used for armor plate, parts of machinery, rails, and wire rope. Cupro-nickel, an alloy of copper and nickel, is used for bullet jackets.

Monel metal contains a higher percentage of nickel and is employed in ship propellers. It does not rust or tarnish, and is finding large use in special parts of machinery, roofing, piping, screens, etc. German silver contains copper, zinc, and nickel. Nickel coins contain copper and nickel.

**Chrome.** Chromium ores are mined in Rhodesia, India, New Caledonia, and Asia Minor. Smaller amounts are produced in Greece, Russia, Japan, and Canada, and in the United States California, Maryland, and Oregon produce some ore. Chromite (oxide of chromium and iron, $FeCr_2O_4$) is the only ore.

The chief use of chromium is as an alloy in steel. It gives remarkable hardness. Chrome steel is used for burglar-proof safes, for hard-edged tools, etc. It resists rust and tarnish and is used in making knives, particularly for kitchen and table use ("stainless steel"). (See stellite under tungsten.)

Chromic acid and bichromate of potash are used in tanning soft kid leather. Salts of chromium are used as dyes and mordants and for pigments (chrome yellow and chrome green).

**Rare metals.** The term "rare metals" has in the past been applied to various elements many of which are today so commonly used that the word "rare" can scarcely be truthfully applied to them. Nevertheless the actual amount of such metals used, measured in pounds, is very small compared with the weight of the iron, copper, or even silver which enters into commerce.

Cobalt is a metal that occurs in small quantities with nickel. It is very important as an alloy in high-speed steel, and forms with chromium and other metals a very hard alloy called stellite. Its compounds are used for coloring blue glass and for making pigments (chiefly cobalt blue and smalt), for painting, printing, and china decoration.

Tungsten (or wolfram) is mined in China, Burma, Portugal, the Federated Malay States, Indo-China, Japan, Australia, Tasmania, Southern Rhodesia, Bolivia, and other countries. In the United States there are deposits in Colorado, California,

Nevada, Arizona, South Dakota, and Alaska. The tungsten ores are wolframite (tungstate of iron, $(FeMn)WO_4$), scheelite (calcium tungstate, $CaWO_4$), and hübnerite (manganese tungstate). The chief use of this metal is in hard-steel alloys, particularly for tools working at high speed. Much of it is marketed as ferrotungsten, the price depending on its percentage of tungsten metal. Stellite is an alloy of tungsten, cobalt, and chromium. Tungsten filaments are used in incandescent electric lamps, and the metal is employed in X-ray tubes and other electrical appliances.

Vanadium ores are found in Peru and in smaller quantities in the United States, Southwest Africa, Northern Rhodesia, Cuba, Sweden, and Argentina. When alloyed with steel this metal imparts hardness and strength.

Molybdenum goes into special steels. Its chief ore, molybdenite (molybdenum disulphide, $MoS_2$), is found in this country in Arizona, Colorado, and California, and also in Canada, Norway, and Australia. Molybdenum wires are used to support the filament in incandescent electric lamps. Molybdenum compounds have been used in dyeing and in staining glass.

Titanium is not an uncommon constituent of iron ores, but is usually very undesirable. Menaccanite is a mineral containing titanium, which, although it contains a large percentage of iron, is almost useless as an ore. The principal ore of titanium is rutile (oxide of titanium, $TiO_2$). Ferrotitanium is used in purifying certain kinds of steel, but when so employed the titanium does not remain in the finished steel. Salts of this metal are used in electrical work, in making leather, in pottery, dyeing, and other industries. During the war titanium was an important element in the production of smoke clouds.

Zirconium forms an oxide that is extremely refractory. It is of much value in making special crucibles and other articles that must resist high heat. Zirconium ores are found chiefly in Brazil, although there are small amounts in this country in Florida, and also in India.

Thorium is obtained chiefly from monazite (a phosphate of cerium and other metals). It occurs also in several less common minerals (thorite etc.). Monazite sand is mined in Brazil, Ceylon, India, in the United States in North Carolina, and in various other places. Its selling price depends on the percentage of thorium it contains. Salts of thorium and cerium are used in preparing the mantles for incandescent gas lamps.

Cerium, lanthanum, yttrium, and similar metals and their alloys are used as sparking-metals for striking fire in cigar-lighters etc.

Mesothorium, extracted from monazite, is a substitute for radium in luminous paint and in medicine.

Uranium ores occur in small amounts in Colorado and Utah in this country (carnotite), in Czechoslovakia and England (uraninite or pitchblende), and in Portugal, Australia, and a few other countries. Salts of uranium are used chiefly for pigments to color glass or porcelain.

Radium is a very rare metal extracted from uranium ores. The chief commercial source of radium is the deposits at Katanga in Belgian Congo. The mines in Colorado have yielded most of the radium ore produced in the United States. This metal has remarkable radioactive properties. Its salts are very important in medical work and are used in luminous paint, particularly for watch dials. (See also mesothorium.)

# NONMETALLIC MINERALS

The distinction between metallic and nonmetallic minerals is an old one but can no longer be sharply drawn. For example, magnesium is used as a metal and in alloys, nevertheless its compounds are usually classed as nonmetallic.

**Magnesian rocks.** Magnesite (magnesium carbonate, $MgCO_3$) is used in making carbon dioxide gas for charging soda water, mineral waters, and beer, and for refrigerating. After magnesite is heated, the residue, called calcined magnesite or magnesia, is made into bricks or concrete and used as refractory lining for steel furnaces and for flooring. Magnesia is also worked into fireproof and nonconducting coatings on steam pipes, and to a small extent into toilet powders.

When carbon dioxide is disengaged from magnesite by sulphuric acid, Epsom salts ($MgSO_4 \cdot 7\,H_2O$) is formed. This and citrate of magnesia are sold in all drug stores. Epsom salts is largely used by dyers. Magnesite and dolomite are both used in preparing sulphite liquors for use in making wood pulp for paper manufacture.

Dolomite (magnesium calcium carbonate) is extensively used as a building-stone under the name of magnesian limestone, or simply limestone. It is harder and more durable than common limestone. Calcined dolomite is used as a lining for iron furnaces.

Talc (hydrous magnesium silicate) is a very soft mineral, easily scratched by the finger nail. It is found as talc rock (steatite or soapstone) in deposits in New York, Vermont, Virginia, California, and many other states, and is imported chiefly from Canada, Italy, and France. It is used in making bath and laundry tubs, sinks, acid tanks (potstone), fire brick, hearthstones, mantels, griddles, slate pencils, tailor's pencils

("French chalk"), gas tips, etc. Powdered talc is employed for foundry facings, as a lubricant, as a dressing for skins and leather, for "finishing" rice, for paints, toilet powders (talcum), and soaps, for sprinkling inside of shoes, gloves, and rubber tires, and as a filler in rubber goods. It is also important as a filler for paper and for dressing cotton fabrics, the fibrous talc (agalite) from New York being used especially for this purpose.

Meerschaum, or sepiolite, a hydrous magnesium silicate, is a claylike mineral found in Asia Minor. It occurs in lumps of irregular shape and is used for carving into pipes and cigar holders.

Serpentine (hydrous magnesium silicate) is a greenish rock found in many parts of the world. It is often used as building-stone. Verd antique is a natural mixture of serpentine with marble. When polished it is used for ornamental work.

**Barite.** Barite, or barytes, is a heavy white mineral (barium sulphate, $BaSO_4$) found in Georgia, Missouri, Tennessee, and other states, and mined also in England and Germany. It is ground to a fine powder and used as a substitute or adulterant for white lead, as a "filling" in rubber manufacture, and for other purposes. A carbonate of barium (witherite) is mined in England.

**Strontium.** Strontium salts are prepared from strontianite (strontium carbonate, $SrCO_3$) and celestite (strontium sulphate, $SrSO_4$), minerals that are found in Great Britain and Germany, and in the United States in Texas, California, Washington, and other states. Strontium hydrate (sometimes barium hydrate) is used in Europe in beet-sugar refining. Strontium nitrate is used in making red fire.

**Lithia.** Lithium carbonate is used in the preparation of medicinal tablets and mineral waters. It is prepared from certain minerals (lepidolite etc.) which in this country are found in California.

**Fluorite.** Fluorite (calcium fluoride, $CaF_2$) is used as a flux in the reduction of metallic ores, in the manufacture of opalescent

glass, in enameling metal cooking-utensils, in the production of hydrofluoric acid, and for minor purposes. It is obtained in Kentucky and southern Illinois and in some parts of Europe.

**Phosphates.** Beds of rock containing greater or less percentages of phosphate of lime, usually associated with carbonate of lime, occur in various parts of the world. Some of these consist of limestone carrying a small percentage of calcium phosphate, and such are not available as a commercial source of phosphorus; some deposits are composed largely of bone and other organic remains; and some are of a coprolitic nature. The phosphatic character of these beds is traceable in most cases to animal origin, if not in all. There are two commercial types, "hard rock phosphate" and "pebble phosphate," the names describing sufficiently the occurrence and the character of the material. Apatite is a crystalline mineral phosphate, valuable when it is found in sufficient quantity. The Florida deposits are of a whitish, pebbly character. The phosphate rock of Tennessee is essentially a limestone from which much of the calcium carbonate has been dissolved. The deposits near Charleston, South Carolina, are distinctly composed of organic remains and contain many shark's teeth, bones, and the remains of marine animals. Other phosphate beds occur in Tunisia, Algeria, Morocco, Egypt, France, Belgium, Spain, Canada, and Australia, as well as in various islands of the Pacific Ocean.

Natural phosphates are used in the preparation of fertilizers. For this purpose they are usually treated with sulphuric acid, which converts the bone phosphate ($Ca_3(PO_4)_2$) into superphosphate (a mixture of calcium sulphate with the acid phosphate of lime, $CaH_4(PO_4)_2$), a form in which it is much more easily soluble in water and hence more available as plant food. The natural phosphates are also used as the source of phosphorus for the manufacture of matches, rat poisons, phosphoric acid, and various compounds (such as phosphate of soda) used in dyeing. Basic slags from some metallurgical furnaces contain

phosphorus and are used in the same way as natural phosphates. Small percentages of phosphorus enter into alloys called phosphor bronze.

**Borax.** Borax (hydrous sodium borate, $Na_2B_4O_7 \cdot 10\,H_2O$) is obtained by recrystallizing crude natural borax (tincal), which occurs in crusts on marshes in central Asia and in the states of California, Nevada, and Oregon. Similar deposits occur in Argentina, Chile, and other parts of South America. Most of the borax used in the United States is made from colemanite (hydrous calcium borate, $Ca_2B_6O_{11} \cdot 5\,H_2O$), a mineral mined in southern California. Borates are also found at Stassfurt, Germany, and in other places. Borax and boracic acid are used for the preparation of glazes, for enameled metal ware, pottery, brick, and tile, in making optical glass, preserving meat, dyeing and tanning, soap-making, medicine, welding, and for many minor purposes.

**Potash.** Potash salts are of immense importance in the preparation of fertilizers. The most important known deposits (carnallite, kainite, etc.) are at Stassfurt, Germany, and in Alsace. There are mines in France, Spain, Italy, and Poland and large deposits in Bengal, India. Potash is extracted from an alkali lake in California. It occurs in such lakes and in brines in Nebraska, Utah, Texas, and other states. It is recovered from salt and soda works in California and Nevada and can be extracted in considerable amount from the waste dust at blast furnaces, smelters, and cement factories. During the World War potash was extracted from kelp (seaweed) dredged from the sea along the California coast. It is also obtained from wood ashes, from sugar-beet refuse, and in wool-washing. It can be prepared by chemical treatment of feldspar.

The numerous compounds of potash (potassium) are used in making soap, glass, and explosives, in dyeing, and in a great many other industries.

**Soda.** Soda, or natron (sodium carbonate, $Na_2CO_3$), is found in nature in small quantities in very dry regions, such as

parts of California, Utah, and Nevada in this country, and in Hungary and Egypt. The natural mineral is unimportant.

Soda ash is the raw commercial form in which soda salts are usually handled. It is a crude carbonate of soda, made by two chief processes known as the ammonia-soda, or Solvay, process and the Le Blanc process. In both of these, common salt is the basic raw material. It is useful in making soap, washing-soda, baking-soda (bicarbonate), caustic soda, and in glass-making, dyeing, and many other industries.

Caustic soda is used in making soap and paper pulp, for mercerizing cotton, and for purifying oils. Silicate of soda ("water glass") is used in making soap and in calico-printing, dyeing, finishing cotton goods and paper, preserving eggs, making cements, wood-finishing, etc. Sodium hyposulphite is used in surgery and photography, in dyeing, and in tanning soft leather.

**Salt.** Common salt includes rock salt, sea salt, and lake salt (halite or sodium chloride, $NaCl$). Rock salt occurs in beds or rock masses in the earth and is mined in lumps, like stone or coal. Large mines of rock salt are located in Poland; at many places in Germany and Hungary; at Cardona, Spain; at Cheshire, England; in Louisiana and Kansas in the United States; and in many other parts of the world. In the Kohat district of India there is a deposit over a thousand feet in thickness. In this country the greatest salt-producing states are Michigan and New York. Large quantities are also obtained in Ohio, Kansas, Louisiana, and California. Salt is manufactured in almost all parts of the world. Owing to its cheapness and wide distribution it is not so important an article in international commerce as staples that are more costly and less common.

When a bed of salt exists at a considerable depth, it is usual to bore a well a few inches in diameter to the bed and to pump water down. Coming in contact with the salt, the water becomes a strong brine, which is pumped to the surface and evaporated. Much of the salt of commerce is obtained from

saline water. Underground lakes or rivers from which the water is drawn through wells yield strong brines in some localities. Ocean water contains about $2\frac{1}{2}$ per cent of salt. At Turks Islands and other places in the West Indies there is a large production of salt from ocean water. Some lakes, such as the Great Salt Lake and the Dead Sea, contain a larger percentage of salt than the ocean. The evaporation of saline water is carried on in large open tanks or vats by the natural agency of sun and wind or else by artificial heat in evaporating-pans. Salt seldom occurs pure in nature, but is generally mixed with calcium sulphate, calcium chloride, magnesium chloride, etc. The presence of these other compounds causes it to absorb water from the atmosphere.

Salt is the most important substance used for flavoring, and it is often classed as a food. It is marketed in grains of different degrees of fineness, such as table salt, dairy salt, and so on. On account of its preservative qualities it is used for packing meat, curing fish, and salting hides. It is used in immense quantities in the manufacture of various chemicals, such as hydrochloric acid, soda ash, carbonate of soda, bleaching-powder, chlorine, chloride of lime, etc., in glazing tile, in the refining of silver, and in other metallurgical and manufacturing operations. Chlorine gas is handled in large quantities compressed in steel tanks. It is used in bleaching, in paper-making, etc. as well as in poison gas for war purposes. Some of the uses of salt are due to its property of producing intense cold when mixed with ice.

**Bromine, iodine.** The concentrated liquor from which salt has crystallized usually contains bromine and iodine and is sometimes worked over for their recovery.

Bromine is recovered in salt works at Stassfurt, Germany, in Chile, and in the states of Michigan, Ohio, and West Virginia. It is important in the preparation of deadly gases for use in war. Potassium bromide and other salts are used in medicine, photography, and the manufacture of coal-tar (eosin) colors.

Fig. 49. Salt Mine in New Iberia, Louisiana

The salt deposits of southern Louisiana are enormous and of high purity. They are hundreds of feet in depth

Iodine is obtained as a by-product at some salt factories and at the Chilean nitrate works. It is also prepared from the ashes of seaweeds (algæ), which are gathered and burned for the purpose on the coasts of Japan and Norway.

**Nitrate of soda.** Nitrate of soda ($NaNO_3$) is an easily soluble mineral which occurs in immense beds in the desert region of Atacama in northern Chile, where rain does not fall for years at a time. The deposits are found at a distance of from ten to twelve feet below the surface. The crude material is transported to extensive works on the seacoast, where the niter is dissolved out with water and recovered in an almost pure state by evaporation. In the purification other salts and iodine are separated.

Nitrate of soda is one of the chief sources of nitrogen. It is used in making glass and in the manufacture of nitric acid, a chemical of great importance, the salts of which are useful in a multitude of ways. Well-known compounds containing nitrogen, often derived from soda niter, are fertilizers, ammonia, saltpeter, gunpowder, fireworks, nitroglycerin, dynamite, and other explosives. Nitrates occur in small amounts in some caves, such as the Mammoth Cave of Kentucky.

**Nitrogen.** Nitrogen is plentiful in the air, but until recent years it was not possible to utilize it from that source. Several different electrical processes are now in use that take nitrogen from the air and combine it with carbon, oxygen, or lime. These processes result in nitric acid, calcium nitrate, and other salts. Cyanides (compounds of nitrogen) are important in electroplating, in the extraction of gold from ores, and in special processes for hardening steel. Cyanamide is a compound of lime, carbon, and nitrogen much used by manufacturers of fertilizers. Sewage, garbage, and slaughterhouse wastes, such as dried blood, hoofs, horns, bone meal, etc., contain nitrogen. Considerable quantities of nitrogen are also recovered in the form of ammonium sulphate in purifying coal gas. The supply of nitrogenous compounds for fertilizers is very essential to the produc-

FIG. 50. Nitrate Works in Antofagasta, Chile

Crude nitrate of soda, or "caliche," is found in the mountainous desert region of northern Chile. It is dissolved in water and recrystallized to free it from impurities. The problem of a supply of water is perhaps the most difficult part of the work in this arid region

tion of all farm crops. The stated analyses of fertilizers always lay stress on the amount of "available nitrogen" or ammonia in the material as sold to the farmer. Certain bacteria that grow in enlargements on the roots of leguminous plants have the unusual property of absorbing nitrogen from the air and making it available as plant food. The culture of these bacteria is a very important part of modern soil fertilizing.

**Sulphur.** Sulphur, or brimstone, is found in a pure state (native sulphur) in the neighborhood of active or extinct volcanoes, and is frequently associated with beds of gypsum and limestone. It occurs impregnating the water of sulphur springs. In chemical combination with various metals it is an important constituent of the large class of compounds called sulphides, which embrace many of the important metallic ores. Native sulphur, pyrite, and the waste calcium sulphide from alkali works are the chief sources of sulphur compounds.

Native sulphur is obtained in the states of Louisiana, Texas, Utah, and Nevada, and in Sicily. There are deposits of less present importance in Chile, Bolivia, Italy, Spain, Russia, Japan, the West Indies, and other places. In recent years Louisiana and Texas have produced the greater part of the world's supply. The method of mining sulphur in Louisiana is not by shafts and tunnels; instead, the underground deposit is reached only by boring wells, down which hot water and steam are pumped. The heat melts the sulphur in the rock, and the pressure of the steam forces the melted sulphur up through a pipe to the surface. In Sicily the ore is partly purified by piling the rock in heaps and igniting it. The heat produced by the combustion of some of the sulphur melts the rest, which runs down and is drawn off from the bottom. Commercial sulphur is marketed in lump form, "roll brimstone," and flour of sulphur, prepared by grinding. Flowers of sulphur is a slightly different article, prepared by distillation.

The most important use of sulphur is in the manufacture of paper pulp, this industry taking three quarters of the total con-

sumption in the United States. Other important uses are in the manufacture of sulphuric acid, gunpowder, and matches, for bleaching, as a disinfectant, and in vulcanizing rubber.

Pyrite (disulphide of iron, $FeS_2$) is an important source of sulphur. This is a brass-yellow mineral mined in large quantities. It is exported from Spain and Portugal and is produced also in Norway, France, Italy, the United States, Germany, Hungary, Japan, and Russia. It is roasted, or "burned," to produce sulphur dioxide gas, which is further treated to produce sulphuric or sulphurous acid. Pyrite often carries copper or gold, and the residue is treated for the extraction of these metals or is used in the making of pigments.

Sulphuric acid (made from sulphur or pyrite) is used in many industrial processes, such as purifying vegetable, animal, and mineral oils, making fertilizers, explosives, coal-tar dyes, and sulphates, such as blue vitriol, copperas, alum, etc. Sulphurous acid is used in making paper pulp and in bleaching and disinfecting.

Disulphide of carbon is a volatile liquid used as a solvent for rubber, sulphur, phosphorus, resins, and oils. It is also employed as an insecticide, especially in wheat elevators.

**Selenium.** Selenium, a by-product in the electrolytic refining of copper, is used in the manufacture of special glass.

**Graphite.** Graphite, plumbago or black lead, is a pure form of carbon. It has essentially the same composition as the diamond. It is called black lead because, like the metal lead, it will leave a mark on paper. The principal sources of supply are Germany, Austria, Czechoslovakia, Italy, Madagascar, Ceylon, Chosen, Japan, Canada, the United States, and Mexico. In this country Alabama, Texas, New York, and Pennsylvania produce crystalline graphite. Amorphous graphite is from Rhode Island, California, Michigan, and Nevada. Crystalline graphite is sold in commercial grades, such as "lump," "chips," "flake," "dust," and "flying dust."

The crystalline grades are used for making crucibles, lead pencils, and lubricants for chains and heavy machinery. The

poorer (amorphous) grades are employed for stove polish, foundry facings, paint, etc. Graphite crucibles are used for melting precious metals and substances that must be exposed to high heat. They are made by molding and baking a mixture of graphite and selected clay. The lead for pencils is prepared by grinding graphite, separating the finest powders,—generally by floating them away in water or in a current of air,—and allowing them to subside. The very finest powder is used for high-grade pencils. Clay is also prepared by floating and is mixed and ground with the graphite in greater or less proportion, the hardest pencils containing the most clay. After the mass is molded in the shape of leads it is baked in a kiln and later glued between strips of cedar. Foundry facings are put on the surface of sand molds to prevent the hot metal from adhering to the sand. Graphite is applied to the hulls of racing yachts and is used for a great variety of other purposes, such as glazing powder grains and shot, dressing felt hats, electrical work, etc.

Graphite made artificially by an electrical process from anthracite coal or coke is used for making electrodes, carbons, paint, and foundry facings.

**Mica.** Mica is a common mineral which occurs as a constituent of granite. It splits readily into very thin sheets and is of value commercially only when it occurs in sheets with an area of at least several square inches. India is the greatest producer of mica. There are important deposits in North Carolina, New Hampshire, New Mexico, and South Dakota in this country, as well as in Canada, Brazil, Argentina, India, and South Africa. Two important varieties found are clear transparent mica (muscovite) and opaque, or dark-colored, mica (phlogopite or biotite). The most important use of sheet mica is for electric insulating. For panels in stove doors and chimneys of incandescent gas lamps only the transparent kind is used. Mica fragments are cemented together (built-up mica) for electric insulation. Scrap mica and trimmings are ground up and usu-

ally mixed with heavy grease for use in lubricating heavy machinery. It also goes into pipe-covering, roofing, and certain kinds of wall paper.

Mica is often miscalled isinglass, which properly means pure sheet gelatin.

**Clay.** Clay is usually a product of the natural decay or alteration of rocks containing feldspar. It varies greatly in composition, like the rocks from which it is derived. It is composed chiefly of hydrous silicates of aluminium, magnesium, and other metals. The purest clay, kaolin, is hydrous aluminium silicate ($2\ H_2O \cdot Al_2O_3 \cdot 2\ SiO_2$). It is used with other substances in making the finest pottery. Less pure clays are used in making tile, earthenware, stoneware, terra cotta, brick, and fire brick. According to uses and properties clays are named as follows: china clay, brick clay, ball clay, pipe clay, sagger clay, and so on. Fire clay is refractory (not easily fusible), and slip clay is useful in glazing pottery because it fuses easily.

Many clays are found mixed with sand and grit, from which they are separated by washing. This process consists of grinding up and stirring the clay in water, which carries off the fine particles in suspension while the coarse part remains behind. The water containing the fine particles is conducted to settling-tanks and allowed to stand until the pure clay is deposited.

Clays are suited for making pottery in proportion to the ease with which they can be molded and shaped when wet and the hard unalterable condition to which they change when they are fired. Many kinds of clay are used in making pottery, and on their nature and proportions and the heat to which they are subjected in firing depends the quality of the resulting product.

In this country Ohio, New Jersey, West Virginia, New York, and Pennsylvania are the most important pottery-making states. Fine wares are made abroad in England, France, Germany, Austria, Japan, and China.

Bricks are made of the common kinds of clay that contain enough sand to prevent undue shrinking. Bricks are burned in

heaps or in kilns, and if the clay contains iron they assume a red color. The leading states that make brick are Pennsylvania, Ohio, Illinois, New York, Missouri, and New Jersey. The kinds that will sustain the greatest heat are called fire brick. Bath brick, made in England, is used for scouring and polishing knives.

Certain clays are used for "loading" paper; others are mixed with limestone in making Portland cement.

Fuller's earth is a peculiar clay used for filtering lard, petroleum and other oils, and in preparing woolen fabrics.

Slates and shales are closely related to clays. They often contain lime, and approach clayey limestone in composition. Slate is a very important roofing material. It is used also for writing-slates, slate pencils, blackboards, mantels, buttons, electric switchboards, etc. Pennsylvania and Vermont produce nearly all the slate obtained in this country.

**Feldspar.** Feldspar is found as a constituent of all granites and similar rocks and it sometimes occurs in moderately pure masses. It is mined in this country in North Carolina, Maine, New Hampshire, New York, California, Connecticut, and other states and in Canada and Norway. Feldspars are silicates of aluminium with other metals, such as potassium, sodium, or calcium; the most common is orthoclase ($K_2O \cdot Al_2O_3 \cdot 6\, SiO_2$).

The chief use of feldspar is in the manufacture of porcelain and similar products. The "spar" is crushed, ground, and passed through fine sieves to prepare it for mixing. It fuses rather easily and is used both in the body of the ware and in the glaze. For high-grade pottery feldspar should be free from iron. The purest spar is an ingredient in making false teeth. Low-grade feldspar is mixed with emery or other abrasives for the manufacture of grinding-wheels; when the wheel is fired, the spar fuses and cements the grains firmly together. Feldspar is used in manufacturing opal glass, and the finest powdered spar goes into scouring-soaps and polishes.

**Granite.** Granite is a name applied commercially to almost all igneous rocks. Typical granite is a mixture of interlocking

grains of quartz, feldspar, and mica; in gneiss the same minerals are arranged in layers; in syenite hornblende takes the place of the mica of granite. Quartz porphyry, andesite, mica schist, diabase, gabbro, diorite, basalt, and trap are all popularly but inaccurately included in the class of granites. These last rocks are chiefly used in the form of crushed stone for paving.

Granites vary in texture from an extremely fine grain to a very coarse grain. In color they are white or grayish, red, yellow, brown, or green, depending generally on the color of the feldspar. Granite is a very hard, strong, and durable rock, susceptible of a high polish. It is much used for building-construction and ornamental work. In this country the states producing the most granite are California, North Carolina, Minnesota, and Massachusetts.

**Limestone.** Limestone is a rock (essentially calcium carbonate, $CaCO_3$) found in beds of great extent in all parts of the world. The purest limestones are white, but many colors are found, generally caused by the presence of iron or bituminous matter. In texture limestones vary from loose to compact and from massive to fine or coarse crystalline. Many limestones are composed almost entirely of fossil shells. Limestone is one of the most important and commonly used building-stones. It is employed also for road-making, railroad ballast, and concrete; as a flux in smelting; for making soda and for other chemical purposes; in glassmaking; for preparing sulphite pulp for paper-making; etc. Indiana, Pennsylvania, Ohio, Illinois, New York, and Michigan are the greatest producers, although limestone is quarried in nearly every state.

Marble in a commercial sense is any limestone suitable for polishing or for use in ornamental work. Many kinds of marble are known by the names of the localities where they are obtained. Carrara marble is the fine, white Italian statuary marble. Tennessee marble is a kind extensively used in this country for ornamental work. Many different kinds of beautiful marble are found in Italy. Vermont is the greatest marble-

producing state in the Union; Georgia and Tennessee produce large quantities. It occurs in a great variety of colors.

Marble dust and chips are used in the generation of carbon dioxide gas ($CO_2$) for charging soda water and other aërated beverages. This gas, compressed in steel cylinders, is an important article, with many industrial uses.

Calcium carbonate sometimes occurs in crystals (calcite). When these are fairly large and transparent they may be broken on their natural cleavage into rhombohedrons which display double refraction. Such cleavages are called Iceland spar. They are valuable for polariscopes and other optical instruments.

Mexican onyx is a translucent limestone with beautiful colors. It is found chiefly in Mexico and Argentina and is used for ornamental purposes.

Stalactites and stalagmites are limestone deposits formed in caves. Travertine is similar.

Lithographic limestone is a variety with a very fine texture. It is found at Solnhofen, Germany, and is used in making lithographic plates.

Lime is produced by burning, or calcining, limestone in kilns. The process of calcining drives off carbon dioxide and leaves quicklime, which is mainly calcium oxide ($CaO$). Quicklime mixed with water becomes intensely hot and crumbles to a hydrated lime known as slaked lime, $Ca(OH)_2$. By long exposure to air either quicklime or slaked lime absorbs carbonic acid from the air and becomes air-slaked lime, approximately $CaCO_3 \cdot Ca(OH)_2$. Common mortar is made by mixing slaked lime and sand with water to form a paste. As the moisture dries out, the mortar "sets," and in the course of time it hardens by the absorption of carbon dioxide ($CO_2$) from the atmosphere. This hardening sometimes continues for a long period, or until all the lime is converted into calcium carbonate. Mortar is generally strengthened by mixing with it cow hair, palmetto, or some other fiber.

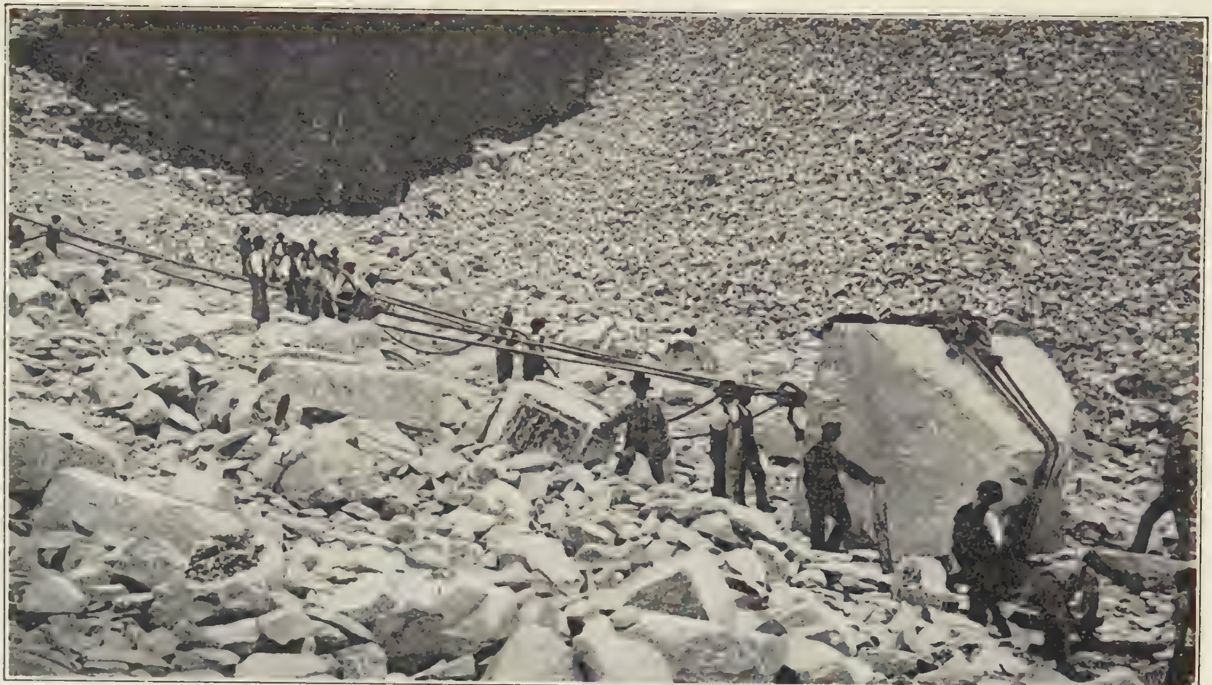


FIG. 51. Marble Quarry in Carrara, Italy

This old locality has furnished an immense amount of beautiful, close-grained statuary marble of the very finest quality

The uses of lime are so varied that only a few can be noted. Among the most important is its use by farmers for treating the soil; by chemists for the manufacture of bleaching-powder, caustic soda, calcium carbide, fertilizers, etc.; for purifying coal gas; in sanitation; for unhairing skins; in making soap, candles, glass, pottery, etc.; in the manufacture of paper and rubber; and in sugar refining.

Chloride of lime, or bleaching-powder, is generally prepared by slaking lime with water and passing chlorine gas through it. It is used for bleaching textiles and paper pulp and for disinfecting. Calcium carbide is prepared by heating a mixture of chalk and coke in an electric furnace. When treated with water this substance liberates acetylene gas, a powerful illuminant.

Hydraulic limestones when calcined, or subjected to heat, yield a lime that will set and harden under water. These limestones all contain siliceous, clayey matter, and, in burning, form certain silicates and aluminates of lime. Hydraulic cements are unlike common lime in that they neither depend on drying for their setting nor on carbonation for their hardening, but combine chemically with a certain amount of water to form insoluble compounds. Hydraulic cements are widely used in construction work, especially in making concrete (a mixture of broken stone with a cement mortar). They are often made from other substances than hydraulic limestone; for example, marls, mixtures of chalk and clay, volcanic tufa and lime, slag and lime, etc.

Portland cement is the most important of the hydraulic cements. It is prepared from mixtures of limestone, either pure or siliceous, with clay. The various substances are powdered and mixed in certain definite proportions. The mixture is thoroughly burned to a clinker, which is afterwards ground to fine powder for use. The use of Portland cement has increased enormously in recent years, especially for the construction of concrete buildings, roads, ships, dams, etc. The

leading producers in the United States are Pennsylvania and California. Its use is world-wide, and rapidly increasing.

Chalk is a peculiar soft limestone resembling white clay. Most of it comes from England. Precipitated chalk is prepared chemically.

Whiting (prepared chalk, putty powder, Spanish white, Paris white) is chalk ground fine and prepared by washing (see under Clay). It is also prepared from some white clays. Whiting is mixed with linseed oil to make putty and is used as an adulterant for other white pigments in paints. Whitewash is sometimes prepared by mixing whiting with water and a little glue, and sometimes by mixing slaked lime and water. Whiting is also used as a polishing-powder.

Marl is a calcareous clay generally containing the remains of many shells and marine animals. It is sometimes used in making Portland cement and often as a fertilizer. The marl of New Jersey is composed mostly of glauconite, or greensand (a hydrous silicate of iron and potassium). It is frequently phosphatic and is used as a fertilizer.

**Gypsum.** Gypsum (hydrous calcium sulphate, $CaSO_4 \cdot 2\ H_2O$) is a soft mineral found in nearly all parts of the world. In the United States it is mined in New York, Iowa, Michigan, Ohio, Texas, and other states. A considerable quantity is imported from Canada. Beds of salt are usually found near gypsum.

Plaster is prepared by calcining gypsum, a process that consists in heating it, thus driving off some of the water it contains. When plaster is mixed with water, they rapidly combine again to make gypsum, and the minute crystals of this substance, in forming, interlace and cause the plaster to "set." The purest calcined gypsum is called plaster of Paris. It is used for making casts and decorative cements. Wall plaster is less pure. It contains sand and fiber and does not set so rapidly as plaster of Paris. Much plaster is used in millboard and pipe-coverings, as well as in many other ways.

Impure gypsum is used in making land plaster and other

fertilizers. Powdered gypsum, or terra alba, is used as a "loading" material in paper-making and textile manufacture and as a pigment in paint.

Alabaster is a compact, pure-white variety of gypsum used for ornamental purposes. It is found in Tuscany, Italy, and in various other places. The alabaster of ancient Egypt and the Bible is a variety of limestone (stalagmite or travertine).

**Quartz.** Quartz (silica, $SiO_2$) is one of the most common minerals. It is found in rock masses (quartzite), in sands and sandstones, and also as clear, transparent crystals (rock crystal). Varieties of many shades of color occur: milky, amethyst, rose, yellow, and smoky. There are many kinds of noncrystalline quartz: jasper, flint, chert, hornstone, honestone, touchstone, buhrstone, petrified or agatized wood, and a great number of semiprecious stones. In addition to forming sandstones and quartzites, quartz occurs as a constituent of many rocks; for example, granite.

American rock flint (pure quartz rock) is mined in Connecticut and Pennsylvania. It is crushed for high-grade silica (silex).

Sand (silica sand) is obtained from beaches (beach sand, lake sand), beds of streams (river sand), and dry deposits (bank or pit sand). Some of it occurs sufficiently pure for use, and some must be washed to free it from clay. The sand grains are sometimes angular (sharp sand) and sometimes rounded. Sand (either natural or crushed rock) is used for making glass and pottery, abrasives (blast sand, silver sand), scouring-soap, sandpaper, furnace lining (fire sand), molds for casting metals (molding-sand), filter beds, and cement and mortar (building-sand). Glass sand is obtained in Illinois, West Virginia, Pennsylvania, New Jersey, Indiana, and other states.

Sandstone is a sedimentary rock composed of grains of quartz cemented together by nature. Sandstones occur in many shades of white, yellow, red, and brown. They are found both loose and compact, fine-grained and coarse-grained. They are used

for building-stone, millstones, grindstones, road-making, railroad ballast, concrete, etc. Some sandstones are crushed to make glass sand. Pennsylvania, Ohio, California, and New York are the greatest producers of sandstone in this country, but it is quarried in almost all the states. Pennsylvania and New York produce a variety called bluestone or flagstone, used for paving. Buhrstone is used for millstones. Honestones, oilstones, whetstones, pulp stones, grindstones, scythestones, and other sharpening-stones are mostly made of sandstone. Arkansas (novaculite), Michigan, Kentucky, Indiana, Ohio, West Virginia, New Hampshire, and Vermont produce most of these articles.

Flint is found in irregular nodules in chalk or limestone. The supply comes from England, France, and Ireland. It is chiefly used in making pottery, being ground to a fine powder and mixed with clay and feldspar. Arrow points and knives were made of flint by primitive peoples. Flint was used with steel for making fire before the invention of matches.

**Glass.** Glass is made by fusing a mixture of silica (glass sand), alkali (generally soda ash), and lime. This mixture makes lime glass. In lead glass (flint glass), lead oxide (minium) is used in place of lime. Sodium sulphate and potash are sometimes used instead of soda ash, and salts of other metals instead of lime or lead oxide. Lead glass is somewhat softer and more costly than lime glass, but it is generally clearer and more brilliant. It is used for fine grades of glassware, particularly for cut glass. Artificial gems (strass) contain a large percentage of lead. Colored glass is made by adding salts of iron, copper, cobalt, or other metals. Iridescent glass (Tiffany glass etc.) contains gold, copper, or other metals. Cooking-utensils and laboratory vessels are made of special glass which is extremely hard, remarkably free from brittleness, and resistant to heat.

Belgium, Austria, Germany, France, and the United States are the leading manufacturers of glass. In this country Pennsylvania, West Virginia, Indiana, Ohio, Illinois, New Jersey,

and New York are the greatest glassmaking states. The abundance of natural gas in certain sections, providing a cheap and desirable fuel, has greatly influenced the location of glass factories.

Articles which look like glass but which will stand still greater heat are made for use in chemical laboratories by the fusing of practically pure silica in electric furnaces. Refractory silica bricks are also prepared.

**Gems.** Precious, semiprecious, and ornamental stones have always been important in commerce. Diamonds, sapphires, and rubies are described farther on. Pearls and mother-of-pearl are usually included in the group. Among the varieties of quartz used for popular jewelry are amethyst, so-called topaz or false topaz, cairngorm, agate, moss agate, jasper, onyx, sardonyx, carnelian, chalcedony, chrysoprase, prase, heliotrope, cat's-eye, and tiger-eye. Other minerals supply topaz, emerald, aquamarine, beryl, tourmaline, olivine, chrysolite, spinel, moonstone, opal, turquoise, and jet.

Ceylon produces ruby, sapphire, spinel, moonstone, olivine, and many other gems. India supplies diamond, sapphire, ruby, carnelian, agate, amethyst, garnet, etc.; Persia furnishes turquoise and lapis lazuli; Russia, topaz, emerald, amethyst, and malachite; Colombia, emerald; Brazil, diamond, topaz, aquamarine, amethyst, agate, and crystal quartz. Rhinestones, beads, spectacle lenses, and crystal balls are cut from clear quartz crystals. Special plates of quartz are used in optical work. Opals come from Australia, Mexico, and Hungary. In this country beryl and amethyst are found in North Carolina and Connecticut; turquoise in New Mexico, Arizona, Nevada, and California; sapphire and ruby in Montana; tourmaline in California and Maine; chrysoprase and kunzite in California; and garnet in Arizona, New Mexico, and North Carolina.

Garnet is mined in opaque masses unfit for gems in the states of New York, North Carolina, and New Hampshire, and in Spain and India. It is a trifle less hard than quartz, and

is an important abrasive used in the forms of wheels, garnet paper, and polishing-powder.

**Diamond.** Diamond is the hardest known substance and is composed of pure crystallized carbon, an element found in almost as pure a state in the form of graphite, and less pure as coal. Diamonds are found principally in South Africa. The chief center of the mining industry is at Kimberley, but there are important producing fields as far north as the Zambezi and in Southwest Africa. Some diamonds are obtained in Brazil and Guiana. Very small diamonds, no larger than the head of a pin, were found in a meteoric iron which fell at Canyon Diablo, Arizona. Minute diamonds have been made artificially in the chemical laboratory.

Clear, flawless diamonds are valued as gems on account of their rarity, hardness, and high refractive power. Their value depends on their size, color, freedom from flaws, and the style in which they are cut. The largest diamond in the world, the Cullinan, when found, was about four inches long and weighed three thousand and twenty-four carats, which is roughly about one and three-quarter pounds avoirdupois. Diamonds are cut and polished by the use of diamond dust. Antwerp and Amsterdam are the chief diamond-cutting centers. Some cutting is done in New York, in Philadelphia, and in South Africa.

Some diamonds are black in color, and many are small, are not transparent, or are of such poor quality that they are useless as gems. These are used for polishing or for cutting hard substances. The black ones (carbonado or bort, chiefly from Bahia, Brazil) are a trifle harder than transparent diamonds and are used for diamond drills. For this purpose they are mounted on the end or edge of a metal tube two or three inches in diameter. This is revolved by machinery, so that, pressing on rocks below the earth's surface, it rapidly grinds or drills a hole. The cores of rock obtained from such wells give valuable information to prospectors and miners as to the nature of rocks and mineral deposits below the surface of the earth.

Diamonds are used for cutting glass, for engraving, and for other purposes, such as truing up grindstones.

**Corundum.** Corundum (aluminium oxide, $Al_2O_3$) is, next to diamond, the hardest natural mineral. In Ceylon and India, and in the United States in Montana, North Carolina, and other places, it occurs well crystallized and transparent, sometimes colorless or blue (sapphire), sometimes red (ruby), yellow, green, etc. These crystals are valuable for gems. Artificial, or synthetic, sapphires and rubies are made in the electric furnace and have the same chemical composition, hardness, and color as the natural stones. It is easy, however, for a gem expert to recognize them, and they sell for lower prices. Artificial sapphires are commonly used for jewels in watches. Reconstructed sapphires or rubies are made by the electrical fusion of fragments of natural gems. These can also be recognized by a gem expert.

Corundum, pure or nearly so, but opaque and therefore useless for jewelry, is mined by the ton in Canada and South Africa and in the states of North Carolina, Alabama, and Montana. When ground into powders of various degrees of fineness it is a valuable abrasive. In the making of grinding-wheels corundum powder of the proper degree of fineness is mixed with clay and other substances which act as cement on firing. Manufactured corundum under many trade names is prepared in the electric furnace in large quantities for use in abrasives.

Emery is a less pure variety which contains considerable iron and is not so hard. It is extensively used as an abrasive. It is found in Greece and Asia Minor, at Chester, Massachusetts, and at Peekskill, New York. As abrasives these minerals are used in powder of different degrees of fineness or are made into wheels, sharpening-stones, cloth, or emery paper, being held together by some cementing material.

**Carborundum.** Carborundum is an artificial abrasive material made at Niagara Falls, New York, by the fusion of a

mixture of coke, sawdust, and sand in an electric furnace. Chemically it is carbide of silicon ($SiC$). Its hardness is greater than that of any other known substance except the diamond. Like other abrasives it is used in the form of powders of different degrees of fineness and for making grinding-wheels and sharpening-stones. It is also used in steel manufacture and for refractory bricks and pyrometers. Essentially the same substance is sold under other trade names.

**Infusorial earth.** Infusorial earth, diatomaceous earth, tripoli, fossil flour, or kieselguhr, is formed of the siliceous shells of a multitude of microscopic organisms. It has essentially the same chemical composition as opal. It is a light, porous, claylike material found in Tripoli, Tuscany, in Virginia and California in this country, and in many other localities. It is used for making polishing-powders, liquid and paste polishes, and scouring-soap, for packing around boilers and steam pipes, for filters, as a filler for rubber goods, and as a base for fireproof cement, plaster, and brick. It has been employed as an absorbent of nitroglycerin in the manufacture of dynamite, but for this purpose it has been replaced by wood pulp.

**Pumice.** Pumice is a volcanic rock, softer than most abrasives. It is used in lump and in powder for polishing metals, plate glass, stone, wood, and varnish. It goes into soaps and cleansing-powders. Much of the pumice used comes from the Lipari Islands off the north coast of Sicily. It is found in California, Utah, and other states.

**Rotten stone.** Rotten stone is prepared from decomposed rocks, such as certain siliceous ferruginous limestones. It is a fine, smooth powder, not of great hardness. It is much used for rubbing down and polishing varnished surfaces, celluloid, and plate glass.

**Water.** Water is one of the most important of all raw materials. Aside from its direct value to man for food, drink, and bathing, its industrial uses are unnumbered. It furnishes moisture for crops, power for water wheels, steam for engines,

and ice for refrigeration; it dissolves hundreds of substances; and it is easily evaporated when its presence is not desired. Almost every human industry depends in one way or another on a fairly abundant water supply.

Water is sold by cities to householders and to factories and by various companies to farmers for irrigation. There is a large trade in bottled natural mineral waters and in pure spring water and distilled waters. Some of these are naturally effervescent, and some are artificially carbonated, or aërated.

Ice, both natural and artificial, is an article which is in growing demand throughout the world.

**Hydrocarbons.** The hydrocarbon group embraces coal, asphaltum, petroleum, and natural gas. These have all resulted from the decomposition of organic matter in the earth. Vegetable matter has been the most important factor in their formation, fossil plants being a prominent feature of many coal deposits. In some cases, however (for example, in certain petroleums and asphalts), it is highly probable that they have been derived, in part at least, from marine or other animal remains.

Porous rocks, such as sandstones, limestones, and shales, not infrequently contain small percentages of bituminous matter. The coloring matter of most black marble is of this nature and was probably derived from the animals the shells of which furnish the lime of the rock.

The form in which these carbon compounds now occur depends on the conditions under which they were deposited and on the influence of time, heat, the pressure of superincumbent rocks, and other agencies to which they have since been subjected.

**Coal.** Coal is in general the result of the gradual change that has taken place during past ages in organic deposits, chiefly vegetable, and its form and composition depend upon the extent to which this change has proceeded. Thus it passes from forms such as peat and lignite, that still retain the structure of the

FIG. 52. Coal Mines in Wales

A glimpse of some of the buildings at the pit head of mines in a region that for many years led the world in coal production

vegetable matter, through those with less of the volatile or bituminous ingredients to anthracite and, further, to kinds that approach graphite. Varieties intermediate between the important types are found.

The most important coal-producing states are Pennsylvania, West Virginia, Illinois, Kentucky, Ohio, Indiana, Alabama, Virginia, and Colorado. Deposits are worked to some extent in most of the states and territories. There are important deposits in Wales (some of which are anthracite), England, Germany, France, Poland, Japan, Czechoslovakia, Belgium, Russia, the Union of South Africa, India, China, Australia, and Canada. Beds of lesser importance or as yet undeveloped are found in other parts of the world.

Peat, or turf, may be considered the first step in the formation of coal. It is formed in bogs and swamps by the partial alteration of leaves, moss, wood, and roots. Peat is a common fuel in the Netherlands, Ireland, Russia, and parts of Germany. It is sometimes made into coke, and the gases derived from it yield a variety of by-products similar to those obtained from coking coal. The World War caused an increase in the use of peat in many European countries. Some peat bogs in Germany have been developed on a large scale by the erection of power plants. The peat is used for the production of fuel gas, and the power station furnishes electric current for various industries. Incidentally many by-products are produced.

In New Zealand kauri peat is distilled for the production of motor fuel, turpentine substitute, and varnish oil. Beds of peat are of comparatively recent origin and contain more or less unaltered vegetable fiber. This is sometimes extracted and made into mats, packing-material, and paper. Fibrous peat from the Netherlands is imported into the United States as bedding for horses and cattle. There are large peat deposits in the United States, but the bogs are mostly undeveloped. In New Jersey and Michigan and on Cape Cod cranberries are grown where it would be possible to dig peat. Sphagnum moss,

COAL

- Gas
  - For fuel and illuminating, making cyanides, Prussian blue, carbon disulphide, etc.
  - Gas lime for fertilizer
- Gas Liquor
  - Ammonia and various salts such as ammonium sulphate, carbonate, chloride, etc.
- Coal Tar
  - Light Oil
    - Benzol
      - Solvents for resins, explosives, motor fuel
      - Pyridine for denaturing alcohol
      - Aniline dyes, including artificial indigo
      - Antipyrine and other medicines
      - Photographic developers
      - Dichlorbenzene (insecticide)
    - Toluol
      - Explosives, TNT, dyes, fruit flavors
      - Oil of mirbane and many perfumes
      - Benzoic acid, benzoate of soda
      - Saccharine
    - Naphtha
      - Solvents for resins, xylol, cleaning-fluids
      - Turpentine substitute, paracoumaron resin
  - Middle Oil
    - Crude Carbolic Oil
      - Phenols, carbolic acid, cresols (medicinal and disinfectant)
      - Insecticides, synthetic resin (substitute for amber), artificial fruit flavors
      - Salicylic acid, artificial oil of wintergreen
      - Picric acid and other explosives
      - Aspirin, resorcinol, and other medicines
      - Metol and other photographic developers
      - Flotation oil, shingle stain, turpentine substitute
    - Crude Naphthalene
      - Refined naphthalene
      - Halowax
      - Explosives
      - Motor fuel
      - Azo dyes
  - Tar and Pitch
    - Paving for roads and sidewalks
    - Roofing, waterproofing
    - Pipe-coating, insulation
    - Paints, varnishes
    - Fuel, briquetting
    - Lampblack
  - Heavy Oil
    - Anthracene Oil
      - Alizarin and other dyes
      - Lubricants
    - Creosote Oil
      - Creosote
      - Wood preservative
      - Shingle stains
      - Disinfectants
      - Insecticides
- Coke
  - For fuel and for the preparation of artificial graphite and lampblack

gathered from the bogs, is used for packing by florists. It has also been used for surgical dressings. Peat moss mixed with beet molasses has been made into cattle feed in Illinois. Muck from peat beds is sometimes used as a fertilizer.

Brown coal is more compact than peat. It contains considerable water and 20 per cent or more of oxygen. It is considered a low-grade fuel. Lignite is a brown coal that retains a little of the structure of the original wood from which it was formed. Brown coal and lignite are mined in some parts of Germany and Austria and in other countries.

Bituminous coal, or common soft coal, generally contains from 5 per cent to 15 per cent of oxygen and from 4 per cent to 7 per cent of hydrogen. There are several types of bituminous coal, the most important of which are as follows: caking, or coking, coal, which becomes pasty or semiviscid in the fire and loses its volatile gases before the combustion of its fixed carbon; noncoking coal, which is similar in appearance and composition to coking coal, but burns freely, without softening or any appearance of fusion; cannel coal (parrot coal, horn coal), which is a compact bituminous coal yielding from 40 per cent to 60 per cent of volatile matter and used in making gas. "Cherry" or "soft" coal, "splint" or "hard" coal, "free-burning," "binding," "block," "gas," and "steam" coals are names applied to varieties of bituminous coal.

Some kinds of coal are used for special purposes for which it has been found that they are best adapted, such as coke-making, steam-raising, gas-making, smelting, and so on.

Anthracite is a hard coal containing a high percentage of carbon and a low percentage of volatile matter. Semi-anthracites are a stage between bituminous coal and true anthracite.

In the United States Pennsylvania produces almost all the anthracite and leads in the quantity and the value of bituminous coal, the output of the latter alone being about equal to the combined output of West Virginia and Illinois, the states which stand next in importance. The value of the anthracite coal pro-

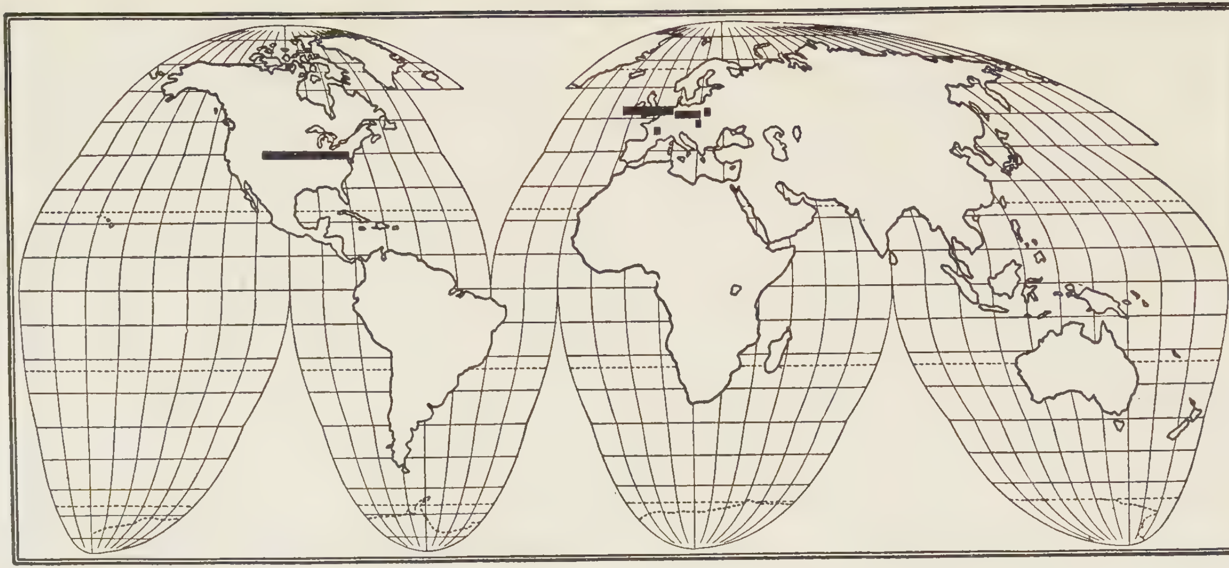



FIG. 53. Map showing Principal Sources by Countries of the World's Production of Coal

Length of bars represents percentages of entire production

duced annually in Pennsylvania is ten times as great as that of all the gold produced in a year in the United States.

In the mining of anthracite coal and its preparation for market by being broken into various sizes (known in this country as steamboat, broken, heater, egg, stove, chestnut, pea, buckwheat, and rice), there is produced a great deal of fine coal dust, "slack," or culm. This used to be piled up in great heaps near the mines and was considered valueless. A considerable amount of it is now being used in firing boilers and is burned in specially constructed grates. It is also used in making coke. A large quantity of coal is separated from pyrite, clay, slate, and coal dust by washing, washeries being often connected with the breakers.

Coal briquets are made of coal dust, culm, or slack (from anthracite, bituminous, or lignite), the small fragments being held together by coal tar, petroleum residuum, liquid asphalt, pitch, or other binder.

Jet is a peculiar variety of coal, so hard and solid and of such uniform blackness that it is cut and polished for jewelry. It is found in Whitby, England, in northern Germany, and in France.

Coke is a fuel prepared from coking coal by partial combustion in ovens. The heat drives off the volatile matter and the sulphur that is often contained in the coal. Coke is of great use in metallurgy, particularly in iron-smelting, because of its porosity, its resistance to crushing, and its comparative freedom from sulphur.

When coke is made in specially constructed by-product ovens, some of the gases which are driven off are burned under the ovens to aid in the coking, and ammonia and coal tar are recovered. The need for certain coal-tar products during the World War did much to increase the use of modern by-product ovens and to discourage the use of the old wasteful beehive coke ovens.

Coal gas, or illuminating gas, is produced by the distillation of coal in retorts. The gases that issue are purified by being

passed through water, which dissolves the ammonia contained in them, and then through slaked lime, which absorbs sulphur, cyanogen, and carbon dioxide. After several re-burnings the lime contains considerable calcium sulphate and is sold as gas lime for fertilizer. Gas-house coke and coal tar are by-products. The coke is different in quality from that already spoken of.

Water gas is made by passing steam over a bed of red-hot coke. It is used for fuel. For illuminating purposes it needs to be enriched (as does also some coal gas) by mixture with benzenes or other volatile products.

Coal tar is distilled, and its products are redistilled and are treated with sulphuric acid, caustic alkalies, and other chemicals. It is impossible to enumerate here all the coal-tar products. The diagram on page 271 takes note of only the most important. As for the uses, there is space to give them only in a general way.

Coal tar is used not only for the preparation of thousands of by-products, but is itself employed in the manufacture of tar paper, tar felt, roofing and building paper, and paint, for tarring ropes, briquetting coal, and road-making, and as a fuel in steel furnaces.

Coal-tar dyes are numbered by the thousand and include anilines, azo dyes, and alizarins. Among these are many of the brightest and most durable colors known; dyes which, when properly used, are "fast" to both washing and light. It is entirely possible to get coal-tar colors that are strong, vivid, brilliant, and harsh, or, if desired, to obtain tints that are rich, soft, and mellow. Much depends on the proper choice of dyes and on the skill of the dyer in their use. Artificial indigo, one of the anilines, has the same chemical composition as vegetable indigo, and alizarin duplicates true madder. Coal-tar dyes are today much more important than the "natural" dyes from vegetable and mineral sources. A limited number of coal-tar dyes, known to be absolutely harmless, are authorized for use in candy, beverages, etc. under the name "pure-food dyes."

Solvents for oils, gums, and rubber, substitutes for turpentine, and fluids for cleaning textiles (benzene, naphtha, xylol, etc.) are all from the light distillates.

Benzene is a base for making oil of mirbane, a fragrant substance used for scenting soap and in the manufacture of aniline. Oil of mirbane almost duplicates the natural oil of bitter almonds. Perfumes which have odors like roses, violets, lilac, and dozens of other flowers, and flavors which taste like peach, apple, blackberry, orange, and vanilla, are largely derived from the light distillates. Methyl salicylate is the artificial oil of wintergreen.

Motor fuels for use instead of gasoline are often derived, at least in part, from the light oil distillate. Similar products are used for enriching illuminating gas. Explosives, so important in modern warfare, are derived from benzol, toluol, and carbolic acid.

Photographic developers, such as hydroquinone, amidol, metol, rhodol, etc., are from the light and middle oils.

The disinfectants, antiseptics, and insecticides, such as carbolic acid (phenol), are largely from the middle oil; so is naphthalene (moth balls). Halowax is an artificial wax derived from naphthalene.

Medicinal products, such as aspirin, antipyrine, and many others, come from the light and middle oils.

Saccharine is hundreds of times as sweet as sugar but is not nourishing.

Pyridine is employed in denaturing alcohol.

The World War did much to develop the manufacture of coal-tar by-products in America and England. Many chemicals and dyes heretofore produced only in Germany are now made equally well in this country. Aspirin is a well-known example. The industry is important not only in providing a domestic supply of these materials and adding to our national wealth in times of peace but also because every one of the great chemical establishments making coal-tar dyes can in time of war be

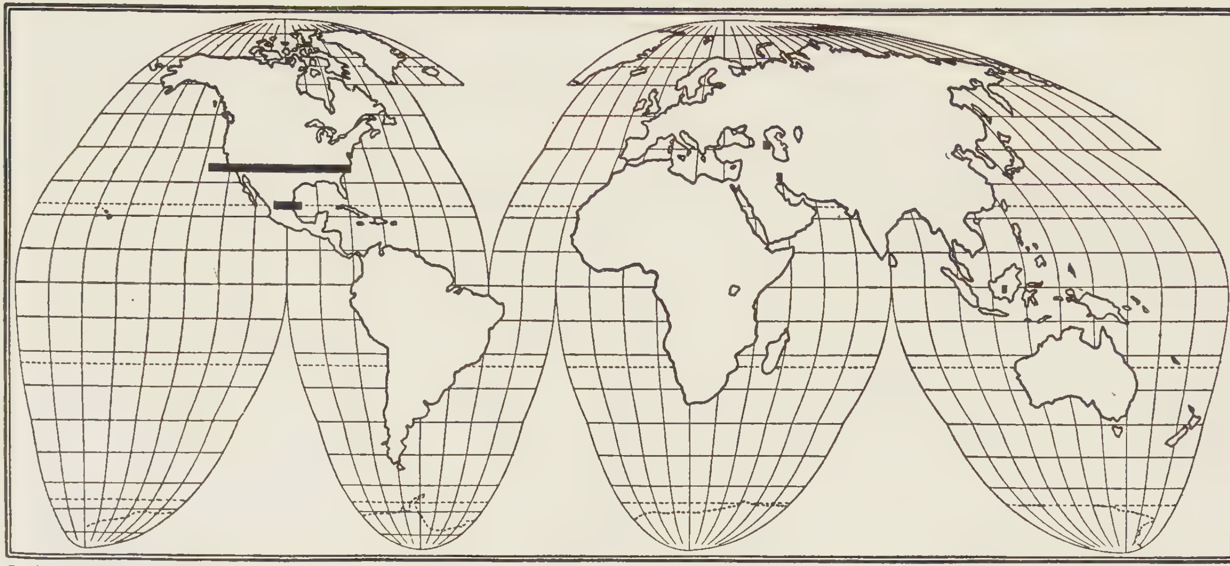



FIG. 54. Map showing Principal Sources by Countries of the World's Production of Petroleum

Length of bars represents percentages of entire production

changed quickly into a place where high explosives and poison gas can be manufactured for our national defense.

**Petroleum.** Petroleum is a liquid bituminous substance produced by the decomposition of vegetable and animal matter in the earth. It varies from a thin translucent oil to a thick, viscous tarry liquid. Petroleum is found in enormous quantities, saturating beds of sandstone, conglomerate, shale, or other porous rocks. Brine is almost invariably found near petroleum, and natural gas is frequently observed.

The United States is the greatest producer of crude petroleum. The most important fields in this country are the Mid-Continent, California, Rocky Mountain, Gulf, Appalachian, Illinois, and Lima-Indiana. Other important producing countries are Mexico, Russia, Peru, Persia, Poland, Rumania, India, and the Dutch East Indies. Petroleum is also produced in Argentina, Venezuela Trinidad, Egypt, British Borneo, Japan, and other countries.

Petroleum is obtained from wells a few inches in diameter sunk through the earth to the porous strata where the oil occurs. The wells vary in depth from several hundred feet to as much as three or four thousand feet, and are driven by means of long, heavy drills. Derricks built over the wells support the drilling-tools. The machinery is operated by steam engines that raise the drills a few inches and then drop them, their sharp chisel-like ends and heavy weight causing them to drive a hole slowly through very hard rocks. The wells are usually lined for at least a part of their depth with cast-iron pipe. Wells for natural gas are bored in the same way. Wells that do not flow freely are often made to yield large quantities of oil by an explosion of nitroglycerin in them. This is called shooting a well.

Crude oil is usually transported on land by being pumped through pipe lines. The pipes run for hundreds of miles from the wells to refineries, most of which are located on the seacoast. From the coast the oil is shipped in tank steamers. Refined oils are shipped by rail in tank cars. Enormous quantities of

FIG. 55. Oil Tanks at Philadelphia, Pennsylvania

At a refinery there are pipes to carry the products to tanks where gasoline, kerosene, and other refined or partly purified oils are stored. In other tanks the oils are purified after distillation, by treatment with acids and alkalies, washing, etc.

refined oil are handled in this country and are exported in square tin cans to all parts of the world.

Crude petroleum varies in quality from light oils, such as those from Pennsylvania, which yield as much as 75 per cent of gasoline and illuminating oils, to heavy oils like the Russian crude, yielding only 35 per cent of the lighter "fractions." The heavy crudes usually yield naphthalene as a distillation product. Still heavier crudes are like liquid asphalt, and some of them are of little use except for fuel oil. Some are used in road-making.

Crude petroleum is refined by being heated in large containers. The vapors which are distilled are condensed by cooling. In this way the petroleum is separated into various fractions, some of them light and easily volatile, like gasoline, naphtha, and benzine; some a little heavier and less volatile, such as kerosene and other illuminating oils; some still heavier oils, used for lubricating. The fractions are further purified by treatment with sulphuric acid and caustic soda and by redistillation.

The lightest oils, pentane and naphtha, are used for making ice and gas, for cleaning textiles, as solvents for rubber and resins, and as substitutes for turpentine. Gasoline is chiefly motor fuel, but is employed for the extraction of vegetable oils and for cleaning fabrics. The word "gasoline" is applied in the United States to a petroleum distillate suitable for motor fuel; in Europe the word "petrol" is generally employed. What is sold under the names "gasoline" and "petrol" is not always a pure petroleum product. It is sometimes composed, in whole or in part, of coal-tar derivatives such as toluol, benzol, naphthalene, etc. The large demand for gasoline and the lesser use of kerosene in the United States have led to the development of a process called cracking. The oils heavier than gasoline are heated under pressure beyond the degree necessary to distill them, and by this means are broken into new chemical combinations. Illuminating oils are sold under various names, such as "kerosene," "headlight oil," "standard white oil," "West-

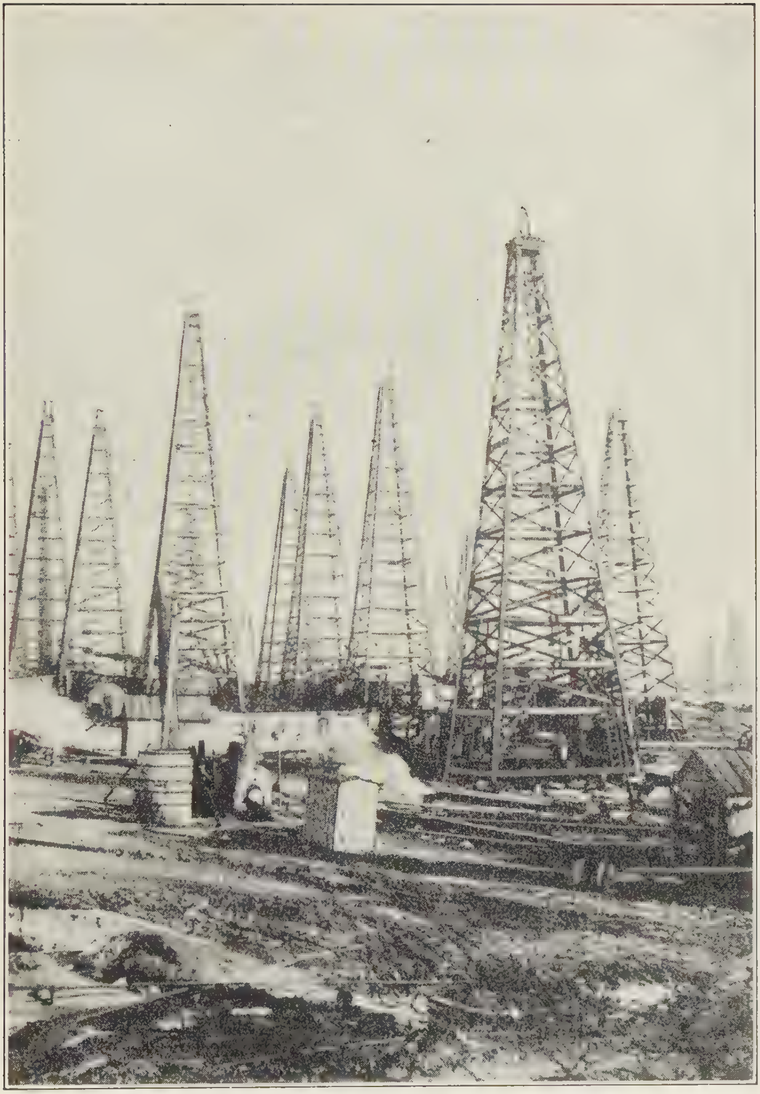


FIG. 56. Petroleum Wells at Goose Creek, Texas

Just a glimpse of a few in a forest of derricks. Engines are pumping up the oil from below. Pipes carry it to settling-basins, where sediment and water fall down and the crude oil is drawn off from the top through other pipes. These connect with pipe lines which convey crude petroleum to refineries as far away as the Atlantic seaboard

minster oil," "miner's oil." The flash point and the specific gravity are two important tests for the lighter petroleum distillates.

Lubricating oils vary from comparatively thin spindle oils, suitable for light machinery, to the heavy oils for cylinders and large engines. The viscosity of oils, tested at different temperatures, is important in determining their value for lubricating. Lubricating oils for all sorts of machinery are prepared by mixtures of petroleum products, sometimes with the addition of vegetable oils. Certain oils are especially prepared for dressing floors, for wool spinning, and for medicinal and other special purposes.

The residuum after distillation is a thick, tarry liquid. It is used as fuel oil and road oil, as a binder for coal dust in briquetting, and is mixed with asphalt for paving. If the distillation is continued at a higher heat, petroleum coke results. This coke is used as fuel and for making electric-light carbons.

Vaseline, petrolatum, petroleum jelly, or other semi-solid greases extracted from mineral oils during the refining process are used in ointments, for oiling papers, and for lubricating.

Paraffin wax is separated in the purification of lubricating oils. The crude wax is commercially termed scale. Paraffin is similar in appearance and in many of its properties to bleached beeswax. It is used for waxing floors and paper, for making candles, for insulating, waterproofing, and as a substitute or adulterant for other waxes.

Ozocerite (native paraffin) is a natural wax found in Galicia. It has been extensively used in shoe polishes. Commercial serecin, or ceresin, is refined from Galician ozocerite. It is very similar to beeswax. The residue is okonite, a substance used for electric insulation. An asphaltic mineral, similar in many ways, called ozokerite, is found in Utah and Colorado.

Montan wax is extracted by solvents from certain lignites in Saxony and Thuringia. Similar waxes are sometimes extracted from peat and shale.

Fig. 57. Asphalt Lake, Trinidad

The pitch lake, of unknown depth, has an area of 114 acres. It was first noted by Sir Walter Raleigh, who used the tar for calking his ships. This and the Bermudez lake, on the mainland of Venezuela, are the chief sources of natural asphalt for paving

There are beds of shale in Scotland that are highly impregnated with bitumen. These do not yield petroleum in a natural flow from driven wells, but are nevertheless an important source of mineral oils. The rock is heated and distilled, and the range of products is similar to that from crude oil. The distillate, which corresponds to kerosene, is commonly called paraffin oil. Immense deposits of a similar nature are found in Colorado, Alaska, and New Zealand. Beds of oil-bearing shale are reported in South Africa, in New Brunswick, Canada, and in China and other countries.

**Natural gas.** Natural gas is found imprisoned in the rocks in the vicinity of many oil fields. It is obtained by boring wells as for petroleum. The chief producing fields are in West Virginia, Oklahoma, California, Pennsylvania, Louisiana, Texas, Ohio, Wyoming, Kansas, and Arkansas. There are gas fields in Canada, Hungary, and China. Natural gas is an important source of heat, light, and power for manufacturing and domestic purposes.

Some natural gas contains a very light, noninflammable gas called helium. At the present time this is the best gas known for inflating balloons.

Some natural gas carries with it enough gasoline to make it possible to separate the latter. This is known as "casing head" gasoline.

**Asphaltum.** Asphaltum, or asphalt, is similar to petroleum in its origin. Some varieties are liquid (mineral tar, or maltha) and some are solid at ordinary temperatures (mineral pitch). No sharp distinctions can be drawn between the heavy varieties of crude petroleum and liquid asphalt. On distillation the latter yields products similar to those from crude petroleum or from coal tar. Liquid asphalts are extensively used in road-making. The name "asphalt" is frequently applied to the residuum from petroleum distillation. Heavy petroleum may change to asphalt by oxygenation and the loss of volatile oils.

The largest known deposits of solid asphalt are the Pitch Lake in Trinidad and another at Guanaco, Venezuela. That from Trinidad consists of about 55 per cent of bitumen with 35 per cent of earthy matter. The most important use of lake asphalt is as a paving material. Asphalt pavements are made of broken and pulverized rock and sand held together by from 8 per cent to 10 per cent of asphaltic cement composed of a mixture of asphaltum and petroleum residuum. Asphalt is used as a cement between wooden paving-blocks. When mixed with broken stone and sand it is compressed into asphalt mastic paving-blocks.

Asphalt occurs impregnating beds of porous sandstone, limestone, and shale. Rock asphalts are mined, chiefly for paving, in the United States in Kentucky, Texas, Oklahoma, California, and Alabama. Similar deposits are worked extensively in Switzerland and France.

Pure varieties of asphalt, "glance pitch," occur in some places. Manjak is from Barbados. A similar variety is found at Matanzas, Cuba. Ozokerite, wurtzilite, gilsonite, and uintahite are from Utah. These pure asphalts resemble pitch and sometimes approach ozocerite. They are used for black varnishes and for waterproof paint, for insulating, for roofing-paper, for mixing with rubber, etc.

Grahamite from West Virginia and albertite from Nova Scotia are related to asphalt. Their chief use is in making roofing-paper.

Elaterite is an elastic bitumen from Hungary. It has been used in paint.

Ichthyol is a medicinal preparation prepared from an asphaltic mineral found in the Tyrol.

# GENERAL INDEX

# INDEX OF LATIN NAMES OF PLANTS AND ANIMALS

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